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Vol. 40 **FEBRUARY, 1954** **No. 2**

FOR ENDURING ARCH RIGIDITY

Extra bearing surface: this is basic reason why Williams-Mershon Multi-Bearing Tubes and Posts give so much more stability to the lingual arch. Note the proportioning of the metal—sharp angles eliminated—a design which affords a firm locking of tube and post to prevent premature wear and looseness...Williams Multi-Bearing Tubes and Posts are precision made of hard gold-platinum precision alloys with special dies to insure perfect interchangeability of tubes and posts over a period of years. Priced same as ordinary tubes and posts. Post available in two types: continuous and partially severed lengths. Illustrated catalog on Williams Orthodontic Materials on request.

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(for lingual arches)

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Original Articles

REPORT OF "ORTHODONTIC CHILDREN" COVERING A PERIOD OF TWENTY-FIVE YEARS

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THIS report is the résumé of data and correlated facts taken from records compiled from 235 cases from many hundreds of cases covering the twenty-five years between 1923 and 1948.

No doubt every orthodontist has observed at some time many of the facts to be listed, but has never recorded them.

To my knowledge, no report of this nature has ever been published or presented, at least to any orthodontic association. Nor when these records were started on patients some twenty-seven years ago was there any idea that a summary of information would be presented many years later.

Thus, in a few words, the data represent collected and correlated information rather than the results of a research project. Nor did I have the proving of any theory or idea in mind.

A number of ideas prompted the drawing up of record forms to obtain data. Tabulating upon these forms the information obtained from patients, we find the following divisions: (1) diet of the mother during pregnancy; (2) diet of the patient; (3) care of the teeth by the patient while under treatment; (4) external tooth pathology before placing appliances; (5) pathology (if any) after appliances were removed permanently; and (6) gingival conditions.

Statements have been made and are continually being made that sugars and carbohydrates are some of the foremost causes of caries. Data collected over the years on this question will be presented later in this article.

I owe my initial incentive to begin the tabulation of nutrition and caries to some lectures on nutrition in 1921 and 1922, and wish here to pay tribute to the author, Mr. George E. Harter, then public relations man of the Ran-

Synopsis read before the American Association of Orthodontists, New York, N. Y., May, 1949.

som and Randolph Company of Toledo. While some of his ideas did not prove to be scientifically correct, nevertheless it was he who imbued me with serious thoughts on nutrition. It was about this time that a few national investigators on nutrition were appearing on the scene. Possessing but little scientific knowledge on nutrition, we felt that any information collected over the years might be of value to those in the fields of dental research and to other nutrition workers in years to come.

Many careless, and certainly thoughtless, statements have been made regarding the detrimental effect of orthodontic treatment upon teeth. This has been especially true regarding teeth which have been banded.

These unfounded accusations, together with the possibility of establishing a relation between caries experience and the amount of sugar intake, fruits and vegetables, mouth hygiene, and heredity, resulted in one of the forms used for collecting this data. The following information is obtained on this record.

1. Nutritional history is obtained from the mother before treatment is started on the child. Particular note is made indicating which of the three classes of foods she favored mostly in her diet, grading them as x (very little), xx (average), and xxx (excessive).

A similar grading is made regarding fruits and vegetables.

Patients' nutritional history is likewise recorded, plus the care of their teeth.

2. Patients are instructed to have a complete checkup by their dentist a week or so before starting treatment, after which tooth and oral pathology records are taken.

3. For consciseness and avoiding error, teeth are numbered 1 (maxillary right third molar) to 16 (maxillary left third molar) to 17 (mandibular left third molar) to 32 (mandibular right third molar).

4. Surfaces are numbered 1 to 5. (1, Mesial; 2, distal; 3, buccal; 4, lingual; and 5, occlusal.)

5. All pathology at the beginning of treatment is indicated in red ink. Any additional pathology at the conclusion of treatment is indicated in black ink. Thus, it is easy to note the type of pathology, if any, which has occurred during treatment and observation while under our care.

6. Unusual pathology is noted separately.

7. The general quality of the teeth is recorded (A+, excellent; A, average; and A– poor).

8. Gingival condition also is noted and rated as – (normal); + (hypertrophied); xx (extremely hypertrophied). So much for this chart.

The buccal and labial surfaces of the patient's teeth are cleaned at each appointment with a powdered dentifrice. Many times the teeth are flossed, and at times scaled, depending upon conditions.

Seldom have we found decalcification on the lingual surface of any tooth necessitating restoration.

We have found the following conditions existing among patients: Some patients take excellent care of their teeth, checked on our chart A+; others are somewhat careless (A); still others disregard constant appeal and warning from parent and orthodontist and are classified as neglectful (A–).

This result of the lack of care is impressed upon the patient and the date of this advice is noted upon our records. Disclosing solution is used on two or three successive occasions to stain food, which we hope will assist the patient in observing food present upon the teeth. It also does one other thing: it leaves a mental impression, for children dislike the taste of this solution.

After three "unhygienic visits," parents are notified by letter of the condition. If no definite and continued determination is made by the patient to improve the situation, after the parent has been sufficiently notified, the case is dismissed.

We aim to clean thoroughly with a powdered dentifrice each tooth that is to be banded, flossing the interproximal surfaces with a wide tape impregnated with flour of pumice, often following this procedure with alcohol.

The teeth are dried with compressed air before bands are cemented. Anterior teeth are completely covered with cement, four to six anterior bands being cemented with one mix. It is the policy, when permanent teeth are banded, to remove and recement the bands at six- to eight-month intervals, allowing a checkup by the patient's dentist, but principally to allow a check on cementation.

Only three standard brands of cement have been used during the past thirty years: Ames, Fleck, and Stratford-Cookson.

Patients are given definite instructions for oral hygiene. They are given a demonstration upon a Typodent with a junior-sized brush (preferably a No. 10 nylon bristle brush); this is often followed by an actual demonstration in their mouths.

We try to impress upon them that the only effective cleaning portions of any brush are the ends of the bristles. This must be in contact with the surface to be cleaned. Once the bristles are bent and the long side comes in contact with the teeth, as in usual patient methods of brushing back and forth, the effectiveness of brushing is lost, especially for patients with labial appliances. To conserve space and the reader's time, the detailed method of brushing will be omitted.

The previous statements should acquaint one with the procedure involving cases about to be discussed.

In a great many of these cases when the first pathologic records were taken only the first four molars and eight permanent incisors were present. (As previously stated, all detailed pathology taken at the beginning of treatment is recorded in red. Pathology, if any, occurring during treatment and observation is recorded in black.)

Naturally there is no pathology (red marks) taken on other permanent teeth which erupt during treatment. Should any of these unerupted teeth require banding later in treatment, pathology, if any, is noted and dated at that time.

Often at the time cases are dismissed we find many teeth showing pathology of which we have no previous pathologic record and consequently this would not be a true picture because, as just explained, records could not be taken on unerupted teeth. If all permanent teeth were present before and after treatment (perhaps excluding the four third molar teeth), the red ink (pathology before treatment) and the black ink (pathology during treatment) would give a true picture of any pathology occurring during the interim.

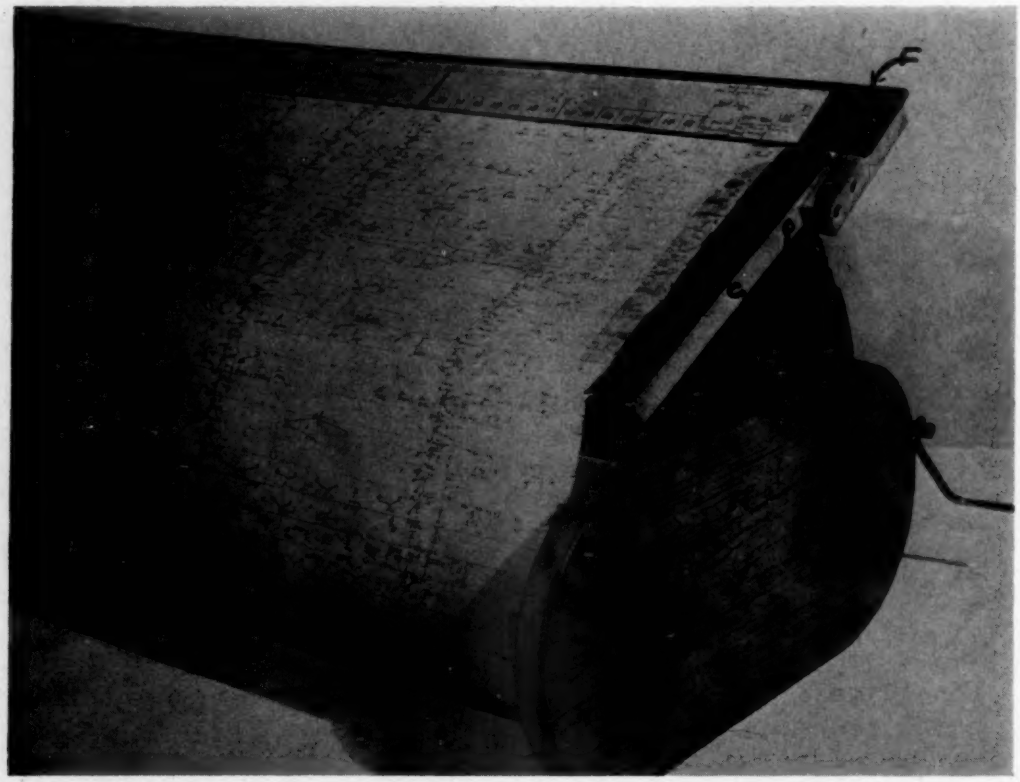

Fig. 1.—The recording machine. This is a wooden framework consisting of two end pieces about 32 inches apart. One end is shown (*A*). These two ends are held together by two pieces of wood, *B* and *B'*. Hinged to *B* is a board 12 inches by 34 inches surfaced by masonite to provide a hard surface upon which to write (*C*). Between the end pieces are two rollers 2 inches in diameter upon which the 30-inch white paper is rolled. This paper, upon which the information is recorded, may be rolled forward or backward to check various data by the two cranks, *D* and *E*.

The strip of masonite, *F*, has listed upon it the type of data which was to be collected. This may be moved from left to right as the columns on the paper may change in either direction when being rolled forward or backward on the rollers.

The dark edge on the roll of paper is cellophane tape which has been used to protect the edges.

There are a number of ways all of these records and information may be cross-checked and additional information obtained which will be noted in the following paragraphs.

Now, the way to record all the information we had gathered on patients, so that comparison of information of one patient with that of any other patient could be easily and quickly done, was one of the immediate problems which nearly "stumped the experts."

To compare one patient's individual record with that of some 200 other individual records with fifty points of information on each patient would be an endless and difficult task, and certainly very confusing.

Therefore, a procedure was decided upon in which all the information of all the patients could be placed upon one piece of paper and whereby a comparison of any portion of one patient's record could be readily made with that of any other patient's record.

DATA RECORDED ON ONE PIECE OF PAPER

Tabulation of the information found in this report was made upon a roll of white paper 30 inches wide and some 35 feet long. I made an apparatus simulating a duplicate order writing machine in which the paper is unrolled by a crank from one roller over a hard writing surface about 1 foot by 2½ feet to another roller. There are fifty columns drawn on this long roll opposite the name of the patient on the left, thereby obtaining fifty bits of information from each patient. This alone was a project because we knew it would be necessary to check and recheck all types of information thus recorded. The paper may be rolled forward or backward to desired records, for comparisons, in a matter of seconds (Fig. 1).

This twenty-five-year report involves some 2,000 cases, but due to change in office personnel during these years a few too many of the fifty points of information on each patient were not recorded on all patients, although much information was used which was recorded (Fig. 2).

Of the patients involved during this period, we have a complete record of 235 tabulated cases.

From these 235 cases we have recorded by individual teeth all the probable external data which are of particular interest.

PATIENTS USING EXCESSIVE CARBOHYDRATES (21 PATIENTS)

From the collected data we have been able to obtain much information. For example, we have segregated patients whose mothers partook of excessive sugars and carbohydrates during pregnancy and those whose mothers took sparingly of sugars and carbohydrates during that period; likewise patients whose mothers ate excessively of fresh fruits and vegetables and vice versa. We have correlated these findings in all four instances.

Then we have correlated the nutrition of individual patients with their own tooth pathology in these four respects, that is, the condition of the teeth of excessive and minimum sugar and carbohydrate eaters when we accepted them as patients and again at the time of dismissal. Similar comparisons were made of the excessive and mild consumers of fresh fruit and vegetables.

From the 235 cases we have tabulated the relation existing between:

1. Decalcification and caries and excessive carbohydrate intake.
2. Decalcification and caries and minimum carbohydrate intake.
3. Decalcification and caries and excessive fruit and vegetable intake.
4. Decalcification and caries and minimum fruit and vegetable intake.

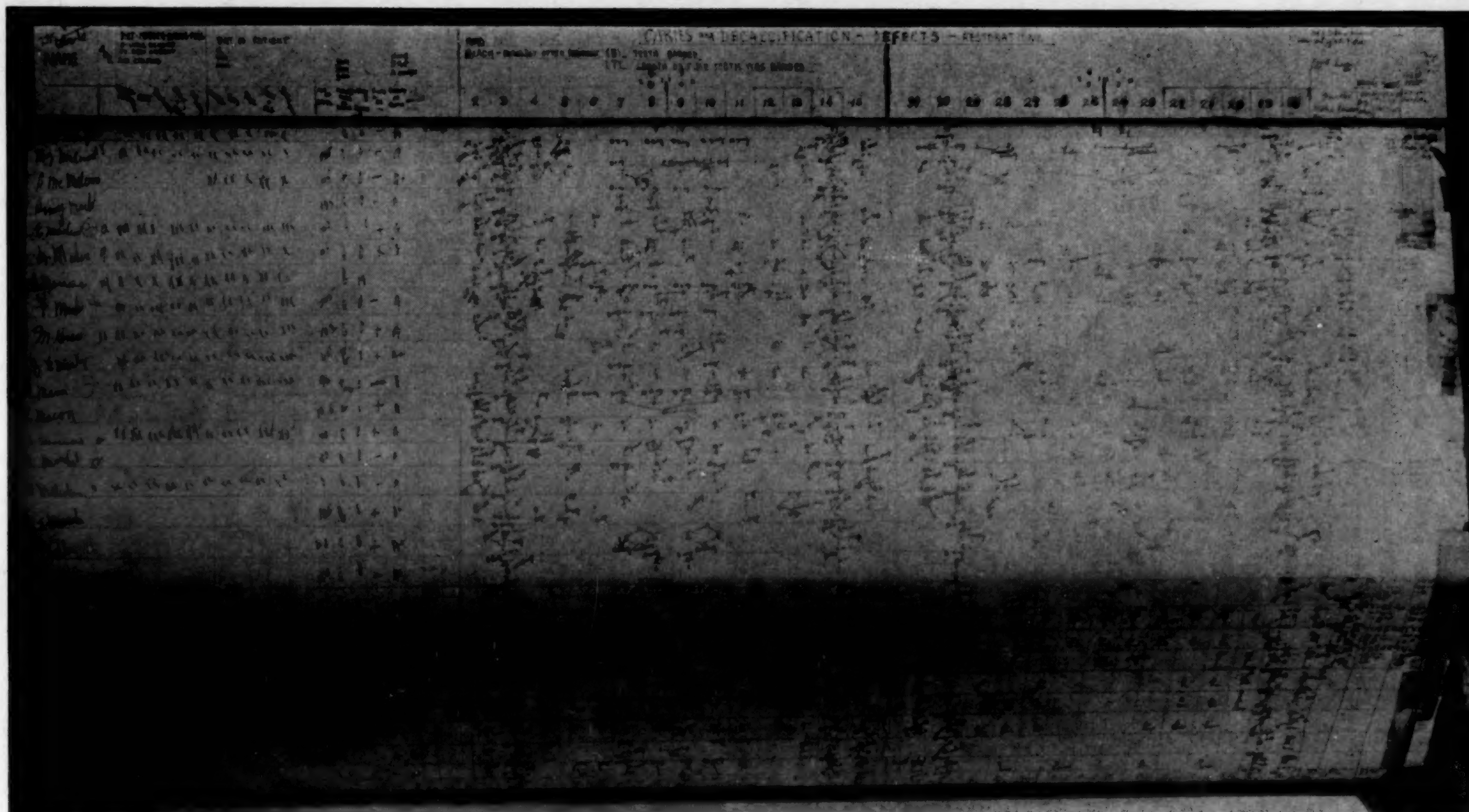

Fig. 2.—Bird's-eye view of the apparatus. Naturally, the red and black colors in recording pathology appear dark. One may note the constant pathologic recordings on the four first molar teeth, Nos. 3, 14, 19, 30, above all other tooth pathology.

In order to render this comparison on a percentage level, we have arbitrarily established as a basis four surfaces of a tooth where decalcification generally takes place, namely, mesial, distal, buccal, and lingual surfaces. Rarely is decalcification found upon the occlusal surfaces or incisal edge.

In each of these cases we have tabulated the percentage of white lines (WL) and fillings (F) before treatment, and the percentage of both forms of decalcification at the conclusion of treatment, together with the years intervening, which is an average of 4.2 years.

From the 235 cases there were only twenty-one patients who partook of the excessive (xxx) amount of carbohydrate and only sixty-nine patients who partook of the minimum (x) carbohydrates.

Decalcified areas are potential caries, and caries preclude fillings.

It is safe to say that one out of ten decalcified areas will eventually be filled within the next three and one-half years. We feel this to be a conservative estimate.

Therefore, if one would take one-tenth of the decalcified areas before treatment (averaging 25.5 per person), we would have 2.5 per cent of the total tooth surfaces (112 surfaces) to be checked off as fewer fillings, namely, 2.5 per cent fillings at the dismissal of the case. This would leave a little less than one filling increase per person, which would be a more accurate picture at the end of the 3.6-year average.

Third molar teeth are not considered in any part of this report.

Decalcification is seldom found on any occlusal surface and therefore only the four vertical surfaces which total 112 (4×28 teeth) are used in computing the percentage of decalcification.

Five surfaces are taken into account when tabulating the percentage of caries and fillings, making 140 surfaces per patient.

From the following one will observe the condensed data.

Excessive Carbohydrate Consumers

(Twenty-one patients with an average of 3.6 years of observation and treatment)

Before Treatment

1. Decalcified areas ranged from 12 per cent to 49 per cent, or an average of 25½ per cent per patient.
2. Fillings varied from ten patients with no fillings to one patient with ten fillings, or an average of about two and one-fourth fillings per patient.

Conclusion of Treatment

1. There were four patients who showed no increase of decalcified areas, up to one with sixteen decalcified areas increase, or an average of 6 per cent increase. This is not a true increase, as approximately one-half of these decalcified areas are on teeth not erupted when the first record was taken.
2. There were four patients with no increase of fillings. There was one with fifteen fillings. (Ten per cent of these additional fifteen fillings are on teeth not erupted at the time of the first record.) This patient possessed no fillings at the start, but did show 16 per cent of decalcified areas at the start which, as stated, are potential

carious surfaces. There was an average increase of five fillings per patient, but again this is not a true increase.

There is a total increase of 103 fillings for the twenty-one patients.

The total number of fillings for patients (with the greatest increase), possessing nine or more fillings, is fifty-seven. Of these fifty-seven fillings, thirty were on teeth not erupted when the first record was taken; or approximately 50 per cent were not actual increased fillings and should not be charged as such. Therefore, taking 50 per cent of the average 5 fillings increase, in reality we would have only an actual increase of 2.5 fillings per patient. Now let us go a little farther. Conservatively assuming that only one of the areas

TABLE I. EXCESSIVE CARBOHYDRATE-CONSUMING PATIENTS (21)

PATIENTS	YEARS UNDER TREATMENT	BEFORE TREATMENT: DECALCIFIED AREAS (PER CENT)	BEFORE TREATMENT: FILLINGS PER PATIENT	CONCLUSION OF TREATMENT: DECALCIFIED AREAS (PER CENT)	CONCLUSION OF TREATMENT: FILLINGS PER PATIENT	
1	5	12	4	7	5	
2	4	14	0	6	2	
3	8	14	6	7	11	4 occlusal F on posterupted; 7 occlusal F on present teeth
4	4	14	5	9	10	6 occlusal F on posterupted; 4 interproximal F on teeth present
5	10	16	0	16	6	½ of DA and 4 of the 6 F were on posterupted teeth
6	6	16	0	4	15	10 of the 15 F were on posterupted teeth
7	3	16	4	2	12	8 of the 12 F were on posterupted teeth
8	1	18	2	0	3	
9	½	20	0	0	0	
10	3	20	0	8	4	
11	5	22	5	10	7	
12	4	26	0	16	9	4 occlusal F on posterupted teeth; 5 occlusal F on present teeth
13	3	30	0	9	7	
14	4	32	5	2	1	
15	1	32	4	7	1	
16	1	33	0	0	0	
17	4	33	1	8	0	
18	2	33	0	7	1	
19	1	40	1	2	0	
20	3	46	0	5	3	
21	3	49	10	1	6	
AVERAGE PER PATIENT	3.6	25½%	2.24 (about 2.25%)	6% increase	5	F increase

decalcified before treatment will become carious within the next three and one-half years, we would have at the conclusion of treatment one less filling per patient or 1½ F increase per patient (2½ F – 1 F, or 1.5 F).

There appears to be no definite pattern in the relation of decalcified areas or fillings in the interim between the start and conclusion of those cases which

may be noted by comparing records of patients (for instance, Patient 4 with Patient 8, or 9 with 16).

Many "increased" fillings, as will be noted here and elsewhere, were the result of (a) pit and fissure conditions, that is, poor union of the enamel; or (b) fillings and decalcified areas in teeth which have erupted after the first records were taken.

MINIMUM CARBOHYDRATE CONSUMERS

(Sixty-seven patients, with an average of 3.7 years of observation and treatment)

Before Treatment

1. Decalcified areas range from 9 per cent to 49 per cent, with an average of 27.1 per cent per patient.

2. Fillings range from thirty-one with no fillings to one with twenty-one fillings, or an average of two and a half fillings per patient.

After Treatment

1. There were twenty-three patients who showed no increase in decalcified areas, up to three who showed an increase of 20 per cent, and nine patients varied between 10 and 14 per cent. The average increase was 4.7 per cent per patient.

2. There were twenty-four patients with no increase in fillings, up to one with twenty-three fillings. Eleven of these twenty-three fillings were on teeth not erupted at time of the first record. Seventeen of the total of twenty-three fillings were occlusal ones. There were seven other patients ranging from 10 to 16 fillings each. There was an average increase of 3.7 fillings per patient. Approximately 50 per cent of the indicated increased fillings occurred on teeth which erupted after the first record was taken. Therefore, taking 50 per cent of the average 3.7 fillings increase, in reality there would be only an actual increase of 1.85 fillings per patient at the conclusion of treatment.

Now again, if we made the same conservative estimate that one of the decalcified areas per patient in the beginning will become carious and filled within the next 3.7 years, we would have a further average reduction of one filling, or there would be an actual average of 0.85 filling (1.85 F-1 F, or 0.85 F) per patient increase in the average of 3.7 years.

Thus, we found that patients consuming excessive carbohydrates at the *beginning* of treatment show about 2 per cent less decalcified areas per patient, and one-fourth filling less per patient than found in the minimum consumers before treatment, which is the opposite of general belief.

At the *conclusion* of cases (approximately three and a half years) the patients consuming excessive carbohydrates showed 1.3 per cent increase in decalcified areas per patient over the patients with a minimum carbohydrate intake, and an increase of three-fifths filling per patient in the excessive, over the minimum, carbohydrate consumers.

An interesting note: We found two patients consuming an average amount of carbohydrate in which 50 per cent of the four surfaces of the teeth involved decalcified areas. One of these patients showed 3 fillings on the first record and increased 11 per cent in decalcified areas and 3 fillings during five years of observation and treatment. The other one possessed no fillings at the start, increased 12 per cent in decalcified areas, and had no increase in fillings after three years of treatment.

TABLE II. MINIMUM CARBOHYDRATE-CONSUMING PATIENTS (69)

	BEFORE TREATMENT			AFTER TREATMENT		
PATIENT	YEARS UNDER TREAT-MENT	DECAL-CIFIED AREAS (PER CENT)	FILLINGS PER PATIENT	DECALCIFIED AREAS (PER CENT)	ADDITIONAL FILLINGS PER PATIENT	
1	2½	9	9	5	5	
2	4	11	0	6	9	
3	6	11	0	4	5	
4	4	11	0	10	4	
5	4	12	21	8	3	
6	2	12	2	2	4	
7	2	13	0	0	0	
8	4	13	0	0	0	
9	6	13	2	11	16	All occlusal F
10	2	14	14	0	2	
11	2	14	2	8	12	9 occlusal 3 interproximal
12	5	15	4	4	0	
13	5	16	0	8	0	
14	4	16	1	3	6	
15	5	16	0	0	0	
16	1	18	5	0	1	
17	6	20	0	8	2	
18	2	20	0	0	0	
19	4	20	2	2	0	
20	6	21	9	7	12	10 occlusal F on teeth not present at start
21	4	23	0	20	3	
22	5	23	3	2	11	8 occlusal F 3 interproximal
23	1	24	0	0	0	
24	3	25	1	0	3	
25	3	25	15	4	5	
26	7	25	1	6	4	
27	6	25	3	8	5	
28	3	25	4	13	12	7 F on teeth not present at start, all occlusal 5 occlusal
29	5	25	6	8	1	
30	4	25	0	0	0	
31	2	25	3	0	0	
32	5	27	3	0	0	
33	3	29	0	0	0	
34	6	30	1	3	1	
35	1	30	0	2	8	
36	3	30	0	20	3	
37	2	30	1	0	0	
38	5	30	1	20	9	All occlusal F 4 F on teeth not present at start 5 F on teeth not present at start

TABLE II—CONT'D

BEFORE TREATMENT				AFTER TREATMENT		
PATIENT	YEARS UNDER TREATMENT	DECALCIFIED AREAS (PER CENT)	FILLINGS PER PATIENT	DECALCIFIED AREAS (PER CENT)	ADDITIONAL FILLINGS PER PATIENT	
39	2	31	3	0	2	
40	1	31	0	0	0	
41	6	32	6	2	3	
42	3	32	2	6	5	
43	3	32	0	0	0	
44	3	32	8	2	11	6 occlusal F on teeth not present at start 5 interproximal
45	1	33	2	6	1	
46	2	33	0	14	5	
47	4	33	0	0	0	
48	3	33	2	3	3	
49	4	33	2	10	10	All occlusal 5 F on teeth not present at start
50	2	33	6	0	0	11 F on teeth not present at start
51	10	33	0	14	23	6 F on teeth not present at start 17 total (all occlusal) 6 interproximal F
52	1	33	0	4	0	
53	2	33	10	12	0	
54	3	33	5	5	3	
55	5	33	0	11	1	
56	4	33	0	0	0	
57	4	33	0	0	3	
58	1	34	2	0	0	
59	1	34	0	4	0	
60	4	34	0	0	0	
61	3	36	0	0	0	
62	4	40	0	7	9	
63	8	40	0	8	9	
64	5	45	2	0	0	
65	4	48	3	3	7	
66	4	49	0	2	4	
67	3	49	0	2	4	
AVERAGE PER PATIENT	3.7	27.1	2.5	4.7	3.7	

TABLE III. COMPARISON OF CARBOHYDRATE CONSUMERS

BEFORE TREATMENT			
EXESSIVE CONSUMERS (21)		MINIMUM CONSUMERS (67)	
1. Decalcified areas (average per cent)	25	1. Decalcified areas (average per cent)	27.1
2. F per patient (average)	2¼	2. Increased F per patient (average)	2½
3. Years under treatment (average)	3.6	3. Years under treatment (average)	3.7

TABLE IV. COMPARISON OF CARBOHYDRATE CONSUMERS

CONCLUSION OF TREATMENT			
EXCESSIVE CONSUMERS (21)		MINIMUM CONSUMERS (67)	
1. Additional DA average per patient (per cent)	6	1. Additional DA average per patient (per cent)	4.7
2. Additional F average per patient	5	2. Additional F per patient	3.7
3. Per cent additional F on teeth *not* erupted at start of treatment	50	3. Per cent additional F on teeth *not* erupted at start of treatment	50
Therefore, the present additional F are 50 per cent of the average 5 F, or	2.5 F	Therefore the present additional F are 50 per cent of the average 3.7 F or	1.85 F
4. Assuming one DA per patient will become carious and later filled, over an average of 3.6 years there would be a further decrease of 1 F average per patient, or an *actual increase* per patient of	1.5 F	4. Assuming that one DA per patient at the start will become carious and filled during the next 3.7 years, over an average of 3.7 years there would be a further decrease of 1 F per patient at conclusion of treatment or an *actual decrease* of	0.85 F

FRUIT AND VEGETABLE CONSUMPTION

We have tabulated enamel conditions in correlation with patients consuming excessive and minimum amounts of fruits and vegetables. Out of 235 patients, only fifty-two indicated an excessive consumption of fruit and vegetables, while only six were minimum consumers.

The following shows the relation of decalcified areas and fillings at the beginning of the case and the relation of decalcified areas and fillings at the end of a three-and-a-half-year average:

The consumers of excessive fruits and vegetables before treatment showed:

An average DA of 25.25 per cent per patient, ranging from 11 per cent to 50 per cent, also an average of 2.3 F per patient, ranging from 1 F to 21 F per patient.

At the conclusion of treatment these same patients showed:

Additional DA of 5.56 per cent per patient, and additional 3.55 F per patient.

Approximately 50 per cent of these additional fillings were on teeth not erupted at the start of treatment. Therefore, in reality the increase per patient would be 50 per cent of the additional 3.55 fillings, or 1.77 fillings increase per patient.

TABLE V. INCIDENCE OF DECALCIFIED AREAS IN EXCESSIVE FRUIT AND VEGETABLE CONSUMERS*

BEFORE TREATMENT		AFTER AN AVERAGE OF FOUR YEARS UNDER OUR CARE	
NUMBER OF PATIENTS	DECALCIFIED AREAS (PER CENT)	NUMBER OF PATIENTS	DECALCIFIED AREAS (PER CENT) †
3	11	16	
1	12	8	2
6	13	1	3
2	18	6	4
13	25		
(and so on to other extreme)		(and so on to other extreme)	
9	33	2	15
2	49	1	17
1	50	1	20
		1	23
Average per patient = 25.5 per cent		Average per patient = 5.56 per cent	

*Fifty-two out of 235 patients.
†After treatment, these patients showed no additional decalcified areas.

Assuming that at least one decalcified area per patient before treatment will become carious and filled within four years, this would make one less additional filling at the conclusion of treatment, or an *actual increase* of 0.77 filling per patient.

The minimum consumers of fruit and vegetables before treatment showed:

An average DA of 26.3 per cent per patient, and an average of 2.3 F per patient.

At the conclusion of treatment these same patients showed:

An average increase of DA of 7.7 per cent per patient, and an average increase of 4.6 F per patient.

Remember again, only the four vertical surfaces of teeth are considered in arriving at percentage of decalcification; the occlusal or horizontal surface is little affected in this manner.

TABLE VI. INCIDENCE OF FILLINGS IN EXCESSIVE FRUIT AND VEGETABLE CONSUMERS*

BEFORE TREATMENT		AFTER AN AVERAGE OF FOUR YEARS	
NUMBER OF PATIENTS	FILLINGS	NUMBER OF PATIENTS	INCREASE IN FILLINGS PER PATIENT
23	0	13	0
7	1	6	1
4	2	2	2
4	3	7	3
2	4	10	4
(and so on to other extreme)		(and so on to other extreme)	
1	8	2	8
2	15	1	9
2	21	2	16
Average per patient = 3.55 F		Average per patient = 2.3 F	

*Fifty-two out of 235 patients.

OBSERVATIONS RELATIVE TO THE INCIDENCE OF DECALCIFICATION

In checking over the pathologic record we have taken of many thousands of teeth, we also find the first permanent molar teeth lead all others in the per-

TABLE VII. INCIDENCE OF DECALCIFIED AREAS IN MINIMUM CONSUMERS* OF FRUIT AND VEGETABLES

BEFORE TREATMENT		AFTER THREE YEARS (NO DIET CHANGE)	
NUMBER OF PATIENTS	DECALCIFIED AREAS (PER CENT)	NUMBER OF PATIENTS	INCREASED DECALCIFIED AREAS (PER CENT)
2	24	2	6
2	25	2	8
2	30	2	9
Average per patient = 26.3 per cent		Average per patient = 7.7 per cent	

*Only 6 out of 235 patients.

TABLE VIII. INCIDENCE OF FILLINGS IN MINIMUM CONSUMERS OF FRUIT AND VEGETABLES

BEFORE TREATMENT		AFTER THREE YEARS	
NUMBER OF PATIENTS	FILLINGS PER PATIENT	NUMBER OF PATIENTS	INCREASE IN FILLINGS PER PATIENT
2	0	2	4
2	1	1	5
2	6	3	7
Average per patient = 2⅓ F		Average per patient = 5⅔ F	

TABLE IX. SUMMARY OF DATA FOR FRUIT AND VEGETABLE CONSUMERS*

EXCESSIVE				MINIMUM			
BEFORE TREATMENT		AFTER TREATMENT		BEFORE TREATMENT		AFTER TREATMENT	
DECALCIFIED AREAS PER PATIENT (PER CENT)	FILLINGS PER PATIENT	DECALCIFIED AREAS INCREASE PER PATIENT (PER CENT)	FILLINGS INCREASE PER PATIENT	DECALCIFIED AREAS PER PATIENT (PER CENT)	FILLINGS PER PATIENT	DECALCIFIED AREAS INCREASE PER PATIENT (PER CENT)	FILLINGS INCREASE PER PATIENT
25.5	3.4	5.7	0.77	26.3	2.3	7.7	4.6

*These figures represent findings in fifty-two individuals who consumed excessive amounts of fruits and vegetables and six who consumed minimum amounts.

TABLE X. COMPARISON OF FRUIT AND VEGETABLE CONSUMERS BEFORE TREATMENT*

	EXCESSIVE CONSUMERS (52)				MINIMUM CONSUMERS (6)			
	RANGE OF DECALCIFIED AREAS		RANGE OF FILLINGS		RANGE OF DECALCIFIED AREAS		RANGE OF FILLINGS	
	NUMBER OF PATIENTS	DA (PER CENT)	NUMBER OF PATIENTS	F	NUMBER OF PATIENTS	DA (PER CENT)	NUMBER OF PATIENTS	F
From	2	11	23	0	2	24	2	0
To	1	50	7	1	2	25	2	1
To			2	21	2	30	2	6

Excessive Consumers: Average DA per patient = 25.5 per cent. Average F per patient = 3.4. *Minimum Consumers:* Average DA per patient = 26.3 per cent. Average F per patient = 2.3.

*Treatment of excessive consumers lasted for an average period of four years per patient, and for an average period of three years per patient in minimum consumers.

TABLE XI. COMPARISON OF FRUIT AND VEGETABLE CONSUMERS AT CONCLUSION OF TREATMENT

FOUR YEARS (EXCESSIVE)		THREE YEARS (MINIMUM)	
1. *Range of Additional DA:*		1. *Range of Additional DA:*	
From 16 patients	0 per cent	From 2 patients	6 per cent
8	2	2	8
To 1	23	To 2	9
Average per patient	5.7 per cent	Average per patient	7.7 per cent
2. *Range of Additional F:*		2. *Range of additional F*	
From 13 patients	0 F	From 2 patients	4 F
10	4	1 patient	5
To 2	16	2 patients	7
Average per patient	3.55 F	To 1 patient	7 F
3. Additional F on teeth not erupted at the start	50 per cent	(on teeth erupted after first record)	
4. Assuming that one DA per patient at the start will become carious and filled within four years, the actual average F increase per patient would be	0.77 F	Average per patient	5.7 F
		3. Assuming that one DA per patient at the start will become carious and filled within three years, the actual average F increase per patient would be	3.6 F

centage of decalcified areas. From these records we have yet to find *one* first permanent molar tooth in over 2,000 cases that did not present a decalcified line (*WL*) on the buccal and lingual surfaces upon the first examination. In other words, every first permanent molar tooth exhibited decalcification on both buccal and lingual surfaces, ranging from a faint white line (*FWL*) to heavy decalcification involving practically the whole enamel surface. Seldom have we found decalcification on the lingual surface of any tooth necessitating restoration.

Following are the teeth in decreasing order of percentage of decalcified areas:

1. First permanent molar teeth (greatest number of DA).
2. Maxillary central incisor teeth.
3. Maxillary lateral incisors.
4. Mandibular incisors.
5. Second molar teeth.

6 and 7. A tossup between cuspids and bicuspids.

We have found lines of decalcification on all second molar teeth, especially the mandibular second molar teeth. These lines traverse the buccal and lingual surfaces diagonally from the distal cusps to the mesiogingival margin. This is attributed to the directional line of the border of the free gingiva during tooth eruption, at which place food has been allowed to remain. Transverse lines generally following the gingival outline are found on many incisors near the incisal third and middle third of the labial surface. We believe they likewise are formed during periods of eruption, due to lack of care at that time and possibly due to local acid disintegration similar to that which occurs in the second molar teeth just mentioned. Approximately one year or so after

the full eruption of permanent teeth the "white line" decalcification has been found only at the gingival, and here again we feel it is the result of the disintegrating process of food left in that area.

On permanent teeth which have erupted during treatment and which have been later observed for some years, the only "white lines" which form after full eruption follow the curvature of the gingiva in that area. These lines vary in degree from a faint white line (*FWL*) to a white surface (*W sur*).

The buccal surfaces of the maxillary second molar teeth hold the record in this respect. Often these surfaces are so decalcified at the time of recording the first pathology that large fillings are necessary before the case is dismissed.

With few exceptions, at the time of the initial pathologic record, we have found either (1) a decalcified area (*DA*), white line (*WL*) or dark area on the mesial surface of practically all first permanent molar teeth. Perhaps the flattened and broad interproximal contact area due to the width of the second primary molar tooth has something to do with this because of cleansing difficulties.

We aim to recement all bands from six- to eight-month intervals and in spite of this precaution, as well as the recementing of loose bands during treatment, we have recorded a few heavy and faint decalcified lines and areas on buccal and lingual surfaces which were not present before the bands were cemented. We have on record less than twenty-five cavities over this twenty-five-year period which we attributed, together with the decalcification just mentioned, to loose bands and areas in which cement had partially dissolved or disintegrated. While the aim is to clean thoroughly the surfaces of teeth to be banded, it is very possible that small areas may be skipped, in which case cement would not adhere, predicating future trouble.

TABLE XII

AT THE TIME OF FIRST RECORD		DISMISSAL RECORDS AFTER 3.7 YEARS (AVERAGE)	
NUMBER OF PATIENTS	FILLINGS RECORDED PER PATIENT	NUMBER OF PATIENTS	NUMBER FILLINGS INCREASED PER PATIENT
54	none	43*	none
14	1	15	1
21	2	16	2
13	3	16	3
(and so on to the other extreme)		(and so on to the other extreme)	
PATIENT NUMBER		PATIENT NUMBER	
156	15	156†	17 (occlusal)
157‡	18	157	21 at dismissal
158§	21	158	23 at dismissal

*Twenty-three of the forty-three had no fillings at start. A further breakdown of 158 (patients with an increase of 23 F). These occurred during a ten-year interval of observation, treatment and observation, and showed beginning of caries (*BC*) on the occlusal surface of 3 and 14 and the buccal surface of 19. There were sixteen decalcifications, none of which were carious. Both mother, during pregnancy, and patient ate carbohydrate sparingly. Their fruit and vegetable intake was average, and the patient took average care of his teeth. Fillings contracted were: 19 occlusal, 2 interproximal, and 2 buccal grooves on molars.

†Patient had no fillings at start.

‡Patient had no additional fillings upon dismissal.

§158 patients had only 3 additional fillings upon dismissal.

Bands are found which apparently are firmly attached to the teeth, but upon removal at the recementing period, a portion of the cement is found missing. Strange as it may seem, decalcification was seldom present on these teeth.

Never have we observed any indication of untoward effects of cements upon many thousands of banded teeth, regardless of the length of contact time involved.

We have a pathologic record of all permanent teeth (excluding the four third molar teeth); length of time each tooth was banded; the number of times each band was removed and recemented, etc. We have recorded decalcifications under headings of white lines (*WL*); white spots (*Wsp*); white surfaces (*W sur*); fillings (*F*); beginning of cavities (*BC*); and cavities (*c*); as well as the surfaces upon which these defects occur—mesial, No. 1 surface; distal, No. 2 surface; buccal, No. 3 surface; lingual, No. 4 surface; and occlusal, No. 5 surface.

TABLE XIII. TOTAL DECALCIFICATION

INCIDENCE OF CARIES (C) IN DECREASING SEQUENCE				
BEFORE TREATMENT			CONCLUSION OF TREATMENT	
TOOTH NUMBER	TOTAL C AT START	ADDITIONAL C AT FINISH	TOOTH NUMBER	DECREASING ORDER OF ADDITIONAL CARIES
30	18	5	30	5
14	9	1	2	3
3	8	3	3	3
9	7	0	4	3
2	4	3	5	2
4	4	3	15	2
5	3	2	29	2
15	3	2	31	2
24	3	1	10	1
26	3	1	14	1
7	2	0	23	1
12	2	0	24	1
31	2	2	25	1
10	1	1	26	1
11	1	0		
21	1	0		
23	0	1		
25	0	1		
29	0	2		
All remaining teeth negative.				

Our records show that the teeth which possess the greatest number of white line decalcification (*WL*) are the four first permanent molar teeth, Nos. 3, 14, 19, and 30.

Out of 158 cases, records of which were complete in all details, we have tabulated the following data:

Average time involved per patient (observation, treatment, and again observation)—3.7 years.

149 fillings were recorded before treatment, an average of 2.6 fillings per patient.

680 new fillings were recorded after treatment, an average of 4.1 fillings per patient.

Actually the fillings per patient are 2.75 F, as explained later.

26.4 per cent of the four surfaces (1, 2, 3, and 4) of all permanent teeth present showed decalcification before treatment.

There was a 5 per cent increase of decalcified areas on the four surfaces during the 3.7 years.

Extremes are noted in the number of fillings (*F*) recorded at the beginning and conclusion of the cases.

TABLE XIV. TOTAL DECALCIFICATION

INCIDENCE OF WHITE LINES IN DECREASING SEQUENCE				
BEFORE TREATMENT			CONCLUSION OF TREATMENT (AVERAGE 4.2 YEARS)	
TOOTH NUMBER	TOTAL WL AT START	ADDITIONAL WL AT FINISH	TOOTH NUMBER	DECREASING ORDER OF ADDITIONAL WL
3	506	9	31	75
14	500	5	15	50
30	485	0	2	41
19	472	17	27	26
8	108	0	11	24
2	86	41	6	20
9	81	1	20	20
7	78	11	5	19
10	76	6	29	19
31	72	75	13	18
13	46	18	12	17
15	43	50	19	17
21	41	8	28	16
5	41	20	18	15
6	40	19	4	11
23	40	6	7	11
25	40	6	3	9
28	40	16	21	8
4	39	11	24	8
24	39	8	26	8
26	39	8	22	7
27	39	26	10	6
12	35	17	23	6
18	32	15	25	6
22	29	24	14	5
11	24	19	9	1
29	23	7	8	0
20	16	20	30	0

At least one-third of these new fillings were replacements of decalcified areas (*DA*) charted at the beginning of treatment on the mesial surface of the four first permanent molar teeth and interproximal surfaces of incisors. This would reduce the *actual* fillings to 2.75 fillings per patient. One third were the result of poor union of the enamel at fissures and sulci, and on teeth not erupted when the first pathologic record was taken.

At first thought one could be of the opinion that appliances might be the indirect cause of these caries, which is not the case, but rather are the result of defects or incomplete or poor union at the junction of enamel centers of

TABLE XV. TOTAL DECALCIFICATION

INCIDENCE OF WHITE SPOTS (Wsp) IN DECREASING SEQUENCE				
BEFORE TREATMENT			CONCLUSION OF TREATMENT (AVERAGE 4.2 YEARS)	
TOOTH NUMBER	TOTAL Wsp AT START	TOTAL Wsp AT FINISH	TOOTH NUMBER	DECREASING ORDER OF ADDITIONAL Wsp
8	95	8	3	36
3	63	36	4	27
14	46	18	2	24
9	42	14	10	21
7	41	14	14	18
30	38	10	29	15
10	33	21	9	14
2	12	24	30	10
4	10	27	15	9
13	9	5	5	8
5	7	8	8	8
6	6	3	12	8
11	5	5	11	5
21	4	1	13	5
25	4	1	22	4
15	3	9	24	4
22	3	4	26	4
27	3	3	6	3
12	2	8	27	3
20	2	2	31	3
24	2	4	20	2
26	2	4	28	2
28	2	2	21	1
31	2	3	25	1
29	1	15	23	0
23	1	0	18	1
18	0	1	19	1
19	0	1	23	0

formation. These enamel junctions are potential caries areas, and were the forerunner of most of the increased caries and fillings at the time of dismissal of the cases.

There appears to be no definite trend in the correlation between the maximum fruit and vegetable intake patients or the minimum fruit and vegetable intake patients and incidence of caries.

During this twenty-five-year period we have found many teeth without visible defects at any time during our care. There was an approximately 1 per cent increase of decalcification on these buccal and lingual surfaces at the time of dismissal of the patients. The total time of treatment and observation averaged 4.2 years.

The recording of all enamel defects, fillings, etc., of the permanent teeth of all patients before and at conclusion of treatment, and the correlating of these findings from various angles with the carbohydrate, fruit, and vegetable intake of each patient has turned out to be an endless and tedious task.

To help simplify gathering, compilation, and the comparing of dates, each erupted permanent tooth is numbered and represented by a rectangular figure. The "tooth" shown in Fig. 3 and Chart 1 represents the accumulated data of one such erupted permanent tooth of the 235 patients.

Each "tooth" is divided into five vertical columns representing the five surfaces of each tooth; and also into six horizontal rows, one for each classification of recorded pathology, at both the beginning and dismissal of the case. Thus, from each rectangular tooth chart we can see at a glance the total pa-

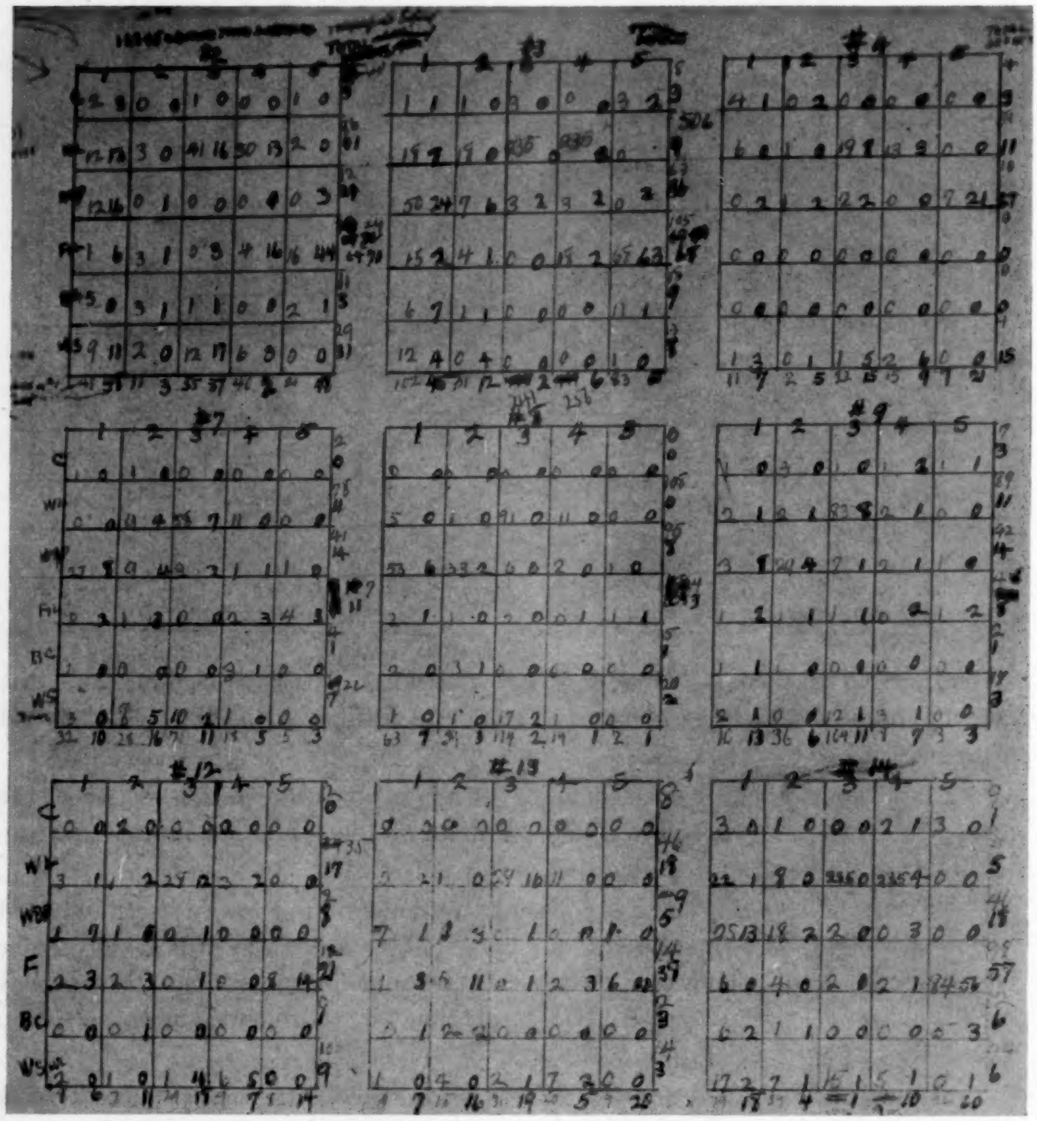

Fig. 3.—Each rectangle represents a tooth. The summary of all tooth pathology is noted on the right and bottom sides of each block or rectangle. The information was taken from the records shown in Fig. 2.

thology of the same tooth of all patients when the cases were accepted and dismissed. It also provides us with the type of pathology present—on which teeth and where, as well as the teeth which were more resistant or immune to destructive forces while the patient was under our care.

SURFACE

PATHOLOGY	#1		#2		#3		#4		#5		
C	1	*1*	1	*0*	3	*0*	0	*0*	3	*2*	8 *3*
WL	18	*7*	18	*0*	235	*0*	235	*2*	0	*0*	506 *9*
WSP	50	*24*	7	*6*	3	*2*	3	*2*	0	*2*	63 *36*
F	15	*2*	4	*1*	0	*0*	18	*2*	68	*63*	105 *68*
BC	6	*7*	1	*1*	0	*0*	0	*0*	11	*1*	18 *9*
W SUR	12	*4*	0	*4*	0	*0*	0	*0*	1	*0*	13 *8*
	102	*45*	31	*12*	241	*2*	256	*6*	83	*68*	

Chart 1.—Surfaces of No. 3 tooth (maxillary right 1st molar).

There are two rows of figures in each column. The numbers in the left row (which are typed on our charts) indicate the total pathologic conditions present on each surface when the first record was taken. The italicized numbers in the right column (which we enter with pencil) indicate the additional pathology, if any, taking place during treatment.

The figures on the outside of each "tooth" represent the total pathology at the start and total pathology at dismissal of all the 235 cases.

TABLE XVI. TOTAL FILLINGS

INCIDENCE OF FILLINGS (F) IN DECREASING SEQUENCE				
BEFORE TREATMENT			CONCLUSION OF TREATMENT (AVERAGE 4.2 YEARS)	
TOOTH NUMBER	TOTAL F AT START	TOTAL F AT FINISH	TOOTH NUMBER	DECREASING ORDER OF ADDITIONAL F
19	122	94	19	94
3	105	68	30	79
14	98	57	2	69
30	93	79	3	67
15	27	51	14	57
2	24	70	15	51
31	20	42	31	42
13	14	38	13	38
18	13	26	29	34
12	12	21	18	26
5	8	19	12	21
7	7	11	5	19
10	6	6	7	11
29	5	34	9	8
8	4	3	11	8
9	4	8	10	6
24	0	1	23	4
25	2	3	8	3
11	1	8	25	3
21	1	2	26	3
22	1	1	21	2
23	3	1	22	1
26	0	3	24	1
4	0	0	4	0
6	0	0	6	0
20	0	0	20	0
27	0	0	27	0
28	0	0	28	0

TABLE XVII. TOTAL DECALCIFATION

INCIDENCE OF BEGINNING CARIES (BC) IN DECREASING SEQUENCE				
BEFORE TREATMENT			CONCLUSION OF TREATMENT (AVERAGE 4.2 YEARS)	
TOOTH NUMBER	TOTAL BC AT START	TOTAL BC AT FINISH	TOOTH NUMBER	DECREASING ORDER OF ADDITIONAL BC
30	21	4	3	9
3	18	9	14	6
14	12	6	15	5
2	11	3	21	4
8	5	1	30	4
10	5	1	2	3
7	4	1	13	3
5	3	0	31	2
9	2	1	7	1
13	2	3	8	1
31	2	2	9	1
18	1	0	10	1
24	1	0	11	1
26	1	0	12	1
15	0	5	19	1
21	0	4	4	0
11	0	1	5	0
12	0	1	6	0
19	0	1	18	0
4	0	0	20	0
6	0	0	22	0
20	0	0	23	0
22	0	0	24	0
23	0	0	25	0
25	0	0	26	0
27	0	0	27	0
28	0	0	28	0
29	0	0	29	0

TABLE XVIII. TOTAL DECALCIFICATION

INCIDENCE OF WHITE SURFACES IN DECREASING SEQUENCE				
BEFORE TREATMENT			CONCLUSION OF TREATMENT (AVERAGE 4.2 YEARS)	
TOOTH NUMBER	TOTAL WHITE SURFACES AT START	TOTAL WHITE SURFACES AT FINISH	TOOTH NUMBER	DECREASING ORDER OF WHITE SURFACES
14	44	6	2	31
2	29	31	15	29
10	27	6	21	15
7	22	7	12	9
8	20	2	3	8
9	17	3	7	7
15	16	29	11	7
22	16	1	5	6
13	14	3	10	6
3	13	8	14	6
25	13	0	28	6
21	10	1	30	6
12	10	9	31	6
5	8	6	6	5
26	8	1	27	4
30	8	6	29	4
24	7	1	9	3
4	4	15	13	3
6	4	5	20	3
20	4	3	8	2
27	4	4	19	2
11	3	7	21	1
18	2	0	22	1
28	2	6	24	1
29	2	4	26	1
31	2	2	18	0
23	1	0	23	0
19	0	2	25	0

TABLE XIX. COMPARISON OF DEFECTS

BEFORE TREATMENT		CONCLUSION OF TREATMENT	
SURFACES	PER CENT OF TOTAL DEFECTS	SURFACES	PER CENT OF TOTAL DEFECTS
Buccal	45	Occlusal	31
Lingual	27	Buccal	29
Mesial	12	Mesial	17.5
Occlusal	9	Lingual	14
Distal	7	Distal	8.5

TABLE XX. TOTAL DEFECTS ON ALL FIVE SURFACES, LISTED IN DECREASING SEQUENCE (235 CASES)

BEFORE TREATMENT				AFTER TREATMENT			
MAXILLARY TEETH	TOOTH NUMBER	MANIBULAR TEETH DEFECTS		MAXILLARY	TOOTH NUMBER	MANDIBULAR TEETH DEFECTS	
R first molar	3		713	R second molar	2		172
L first molar	14		709	L second molar	15		147
	30	R first molar	663	R first molar	3		133
	19	L first molar	474		31	R second molar	126
R central incisor	8		232		30	R first molar	104
R second molar	2		169	L first molar	14		93
L central incisor	9		161		29	R second premolar	74
R lateral incisor	7		154	L second premolar	13		67
L lateral incisor	10		145	R second premolar	4		57
R second molar	31		100	L first premolar	12		56
L second molar	15		92	R first premolar	5		55
L second premolar	13		87	R lateral incisor	7		45
R first premolar	5		70	L canine	11		45
L first premolar	12		61		18	L second molar	42
	25	R central incisor	60	L lateral incisor	10		41
R second premolar	4		57	L central incisor	9		40
	21	L first premolar	57		27	R canine	33
	26	R lateral incisor	53		19	L first molar	31
	24	L central incisor	52		20	L second premolar	26
R canine	6		50		28	R first premolar	24
	22	L canine	49	R canine	6		17
	18	L second molar	48		26	R lateral incisor	17
	27	R canine	46		21	L first premolar	16
	28	R first premolar	44		24	L central incisor	15
	23	L lateral incisor	42	R central incisor	8		14
L canine	11		34		22	L canine	13
	29	R second premolar	29		25	R central incisor	9
L second premolar	20		22		23	L lateral incisor	8
Total			4473				1520

R = right.
L = left.

TABLE XXI. LIST OF TOTAL DEFECTS AND FILLINGS IN DECREASING SEQUENCE

BEFORE TREATMENT		AFTER 4. 2-YEAR AVERAGE	
SURFACE	DEFECTS AND FILLINGS	SURFACE	DEFECTS AND FILLINGS
3	2,010	5	472
4	1,214	3	450
1	546	1	266
5	409	4	203
2	294	2	129
Total	4,473	Total	1,520
Average defects and fillings per patient = 21 per cent		Average defects and fillings per patient = 7 per cent	

Total number and type of defect on each erupted permanent tooth, before and at conclusion of treatment of 235 patients.

The typed figures on the right side of the "tooth" indicate the totals of the six classified enamel defects present on that same tooth of all patients at the start of the case. The italicized figures on the right side of the "tooth" indicate the totals of the six classified enamel defects on that same tooth of all patients at the conclusion of treatment.

The outside bottom figures give the total number of defects accumulated on each of the five surfaces.

Here again one is able to see at a glance the surfaces which are affected the most and by which type of defect.

Also, one can readily see which of the six pathologic conditions predominate in each tooth of all cases.

As one might expect to find, the surfaces of many teeth are negative, while some show a consistent positive record.

In order to have a fair picture of the increase in fillings, the potential source of fillings before treatment should be reviewed. Caries and incipient caries at the start definitely mean fillings at a later time, and these total 116. If we deduct these from the 621 fillings at the finish of the cases we would have 505 fillings, or an equivalent of 1.7 fillings per patient increase over 4.2

TABLE XXII. TOTAL PATHOLOGY ON EACH

BEFORE TREATMENT (B) AND CONCLUSION

TOOTH NUMBER		2	3	4	5	6	7	8	9	10	11	12	13	14
#1 Surface	(B)	41	102	11	13	7	32	63	10	38	1	8	9	79
	(C)	48	45	7	6	3	10	7	13	13	5	6	7	18
#2 Surface	(B)	11	31	2	6	10	28	39	36	20	2	7	18	39
	(C)	3	12	5	8	3	16	3	6	3	4	11	16	1
#3 Surface	(B)	55	241	22	26	27	71	114	104	75	30	29	31	254
	(C)	37	2	15	14	9	11	2	11	7	29	18	19	1
#4 Surface	(B)	41	256	15	15	5	18	14	8	10	0	9	20	245
	(C)	36	6	9	12	2	5	1	7	11	2	7	5	10
#5 Surface	(B)	21	83	7	10	1	5	2	3	2	1	8	9	92
	(C)	48	68	21	15	0	3	1	3	7	5	14	20	60
TOTALS														
Before		169	713	57	70	50	154	232	161	145	34	61	87	709
Conclusion		172	133	57	55	17	45	14	40	41	45	56	67	93

LOCATION OF FILLINGS

BEFORE TREATMENT		CONCLUSION OF TREATMENT	
SURFACE	PER CENT OF TOTAL FILLINGS	SURFACE	PER CENT OF TOTAL ADDITIONAL FILLINGS
Occlusal	75½	Occlusal	74.5
Mesial	8½	Mesial	7.6
Distal	7	Distal	7.6
Lingual	6	Lingual	7.5
Buccal	3	Buccal	2.8

years, instead of 2.6 fillings per patient. The areas marked "white spots" are definite potential cavities requiring fillings later. At least 90 per cent of these are found on the interproximal surfaces of the eight incisor and four first molar teeth. Our records show a decided increase of fillings on these and occlusal surfaces of all molar teeth.

We have tabulated some 2,000 cases, in which more than 8,000 first molar teeth, 1,500 second molar teeth, and 16,000 incisors are involved. They follow the same pattern as the 235 cases, in which we find in *decreasing order* the six recorded pathologic divisions: (1) caries; (2) white line decalcification; (3) white spot decalcification; (4) fillings; (5) beginning caries; and (6) white surface decalcification.

There are approximately one-third additional total defects over the 4.2-year average. These defects are divided into the following groups:

Beginning:		*Finish:*	
C	60—1 C for every fourth patient	C	18—1 C to each thirteenth patient
WL	3090—13 WL for every patient	WL	445—1.5 WL to each patient
Wsp	413—1.7 Wsp for every patient	Wsp	241—1 Wsp to each patient
F	570—2.4 F for every patient	F	621—2.6 F to each patient (actual 1.7 F per patient explained below)
BC	55—1 BC for every patient	BC	36—1 BC to about each seventh patient
W sur	285—1.2 W sur to every patient	W sur	159—1.5 W sur to each patient
Total	4,473	Total	1,520

OF THE PERMANENT TOOTH SURFACES

OF TREATMENT (C) OF THE 235 CASES

15	18	19	20	21	22	23	24	25	26	27	28	29	30	31	BEFORE	AFTER
4	6	1	2	7	3	3	4	3	4	3	2	2	82	6	546	
12	8	2	0	1	1	1	2	1	2	1	0	14	22	11		266
1	3	1	1	4	1	2	2	2	2	4	3	2	13	4	294	
4	3	2	2	0	2	0	1	0	2	0	0	18	1	0		129
47	22	235	19	41	45	31	40	49	40	39	28	15	243	37	2,010	
54	12	18	23	9	10	6	9	7	10	32	19	21	2	43		450
13	11	235	0	4	0	4	0	4	1	0	10	8	236	32	1,214	
26	4	4	1	4	0	0	0	0	0	0	5	1	3	42		203
27	6	2	0	1	0	2	6	2	6	0	1	2	89	21	409	
51	15	5	0	2	0	1	3	1	3	0	0	20	76	30		472
92	48	474	22	57	49	42	52	60	53	46	44	29	663	100	4,473	
147	42	31	26	16	13	8	15	9	17	33	24	74	104	126		1,520

SUMMARY

Total permanent teeth observed	4,468
Total permanent teeth present before treatment	3,465
Total defects present before treatment	4,478
Average defects per tooth	1 1/3
Total additional permanent teeth present at conclusion of treatment	1,003
Total additional defects present at conclusion of treatment	1,520
Average additional defects present at conclusion of treatment	1.5
Approximately 50 per cent of the defects present at the conclusion of treatment are on teeth which erupted after the first record was taken. Therefore the *actual increased* defects per tooth are	0.75
Total tooth surfaces observed before treatment	17,325
Per cent of tooth surfaces involved before treatment	25.75 per cent
Total additional tooth surfaces observed at conclusion of treatment	5,015
Per cent of additional tooth surfaces involved at conclusion of treatment	3 per cent
As stated previously one-half of the "additional" defects (or surfaces) occur on posterupted teeth; therefore, the *actual increase* would be	1.5 per cent

RATIONAL APPROACHES IN ORTHODONTIC DIAGNOSIS

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Although anything that can be said about orthodontic diagnosis at our present stage of advancement may be considered trite, it is almost universally agreed that periodic re-examination and evaluation of any accepted procedure or belief is worth while.

It would appear that if diagnosis is to be approached in a rational manner, it is well to discuss and eventually agree upon the following points:

1. What should an orthodontic diagnosis include?
2. What fundamental knowledge is needed upon which to base a diagnosis?
3. What is the contribution of normal standards to diagnosis?
4. What is the contribution of diagnostic aids to diagnosis?
5. What is the value of a classification to diagnosis?
6. What is the step-by-step procedure in making a diagnosis?

One idea that should be stressed immediately is that the diagnosis should be as thorough as necessary, but should not be unduly involved. There is only one circumstance under which the patient is cared for completely by a correct diagnosis alone, and that is when the diagnosis reveals that no treatment is indicated. It is also true that many deformities, perhaps the majority, offer no undue diagnostic problems, but still it is necessary to be alert at all times to the necessity of a differential diagnosis because unusual conditions are found frequently in what appears to be a simple or so-called typical case.

What Should an Orthodontic Diagnosis Include?—How each of us thinks about any phase of orthodontics is dependent upon our background, that is, upon our training and subsequent experience. Undoubtedly, those who have been treating dentofacial deformity for some time allow the treatment results which seem possible for them to influence their whole outlook on orthodontics and, therefore, on diagnosis. This would not be true for those who, like Strang,[1] insist that diagnosis is complete as soon as any deviation from the normal is detected, since this establishes the fact that there is a deformity. He considers all other aspects of the condition under the heading of case analysis which is, in a way, a good division, since it definitely sets off diagnosis from treatment. However, it would seem that the diagnosis well might include, in addition to the detection of a deformity, how and to what degree the condition differs from the normal, and also the cause of the deformity. The more nearly prevention of dentofacial deformity is

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approached, the more it will be necessary to understand and uncover the causes in order that they may be removed, if possible, and thus not allow a deformity to occur. Perhaps, in addition to the consideration of the physical deformity, the significance of the physiologic, psychological, and social factors should receive much more attention than they do now. If these were agreed upon, it would mean that all considerations relative to the patient would be included in the diagnosis, except how treatment, if needed, is to be carried out and how retention, if any, is to be employed.

What Fundamental Knowledge Is Needed Upon Which to Base a Diagnosis?—The ability to recognize deformity is directly dependent upon a knowledge of the normal individual. In order not to diagnose a normal growth pattern as a deformity, it is necessary to know the changes that occur with growth in the face and dental arches, and the stage of growth expected for any given age and sex.

This normal or expected growth is not attained by many individuals because certain etiologic factors interfere with the amount of growth or divert the inherited pattern. Some have assumed that all dental or dentofacial deformities are inherited, but most now agree that they may occur from acquired causes, either local or systemic in nature. It is well that the novice be familiar with these possible causes in order that they may be discovered and eliminated, or at least minimized, whether or not deformity already has been produced. A diagnosis must be based, then, upon an understanding of the normal individual and of etiology as it relates to abnormalities.

What Is the Contribution of Normal Standards to Diagnosis?—To understand the normal individual, we must know some normal standards. Studies of facial growth and the determination of the status achieved by each sex at any given age have provided considerable information from which certain usable growth standards have been compiled. These may be called normal standards and some are available in the form of charts, photographs, drawings, or other visual material that can be kept constantly on hand for reference. These normal standards, when used judiciously, are of great value in diagnosis as an aid in determining whether a given patient is equal to, above, or below what should be expected for his age and sex. In addition, they may be used as supporting evidence to point out how the patient differs from the normal and what changes are necessary to obtain the desired condition.

Some objection to the use of normal standards is raised on the basis that faces are different and that it is wrong to attempt to turn our patients out of the same mold. This certainly is not the intention, nor would the use of the standards in this way be justified. Our purpose in comparing with the normal is to determine how our patient differs, not whether through our therapy we can make him conform to a so-called normal or average pattern. When we say the patient differs, the next logical question is, "Differs from what?" Whether we admit it or not, in making a diagnosis it is unavoidable

that we compare the morphologic conditions found in the patient with our concept of an acceptable equilibrium between the size and form of the structures involved and their relationships to each other. This comparison occurs, whether our standard is an intangible image conjured up in our minds or is evolved through the study of normal individuals and set down in the form of measurements, tables, photographs, or charts. The advantage of the latter is that they are objective rather than subjective and that they provide a means of conveying to our colleagues, students, and patients a concept of the normal that means the same to all.

Some of these concepts or normal standards are of value as starting points or planes from which the relationship of the dentures, face, and cranium may be judged. The quest for a starting point that can be used as a rule of thumb for judging dentofacial relationship is uppermost in the minds of many of us, and, if ever discovered, would be an outstanding contribution to orthodontics. It is interesting to note that there is only one concept of the normal that is universally accepted and upon which there seems to be complete agreement, namely, that the posterior teeth have a definite buccolingual and mesiodistal relationship or interdigitation, which is frequently, but perhaps incorrectly, referred to as normal occlusion.

Such an interdigitation or intercusping is possible within a comparatively wide range of denture-to-basal-bone or cranial relationships. This indicates the need to determine a normal or acceptable position of the denture in the skull, which in turn requires some starting point, plane, or structure by which this location may be judged. Angle[2] suggested the maxillary first permanent molar, because of its supposed constancy of position, as the starting point from which to judge the relationship of the denture to the skull, but he failed to give any actual anatomic relationship of this molar to the skull. Atkinson[3] pointed out that this molar, when normally positioned anatomically, is found to have "the mesiobuccal root conform to the graceful curve of the zygoma or key ridge." Klaatsch[4] and Pfaff[5] state, however, that "in prognathic races the distal roots of the maxillary first molars are usually situated in the zygomatic crest'' and that in the case of orthognathism ''usually the mesial root is so situated." Quite often in the living it is difficult to determine how the maxillary first permanent molar is related to the crest of the zygoma.

A good definition of how the teeth should relate if in normal occlusion is given in Angle's line of occlusion and the position of this line is described relative to the teeth, but is not related anatomically to the skull. Simon,[6] through the use of anatomically determined planes, located the denture in the skull and found that in the majority of his cases of German subjects with acceptable dentofacial relationships the orbital plane passed through the maxillary cuspid. This contention was substantiated in a recent study by Knarr,[7] but Simon's so-called law of the canines unfortunately is not widely accepted.

Tweed[8] and others used the upright position of the mandibular incisors over basal bone as a starting point from which to judge the relation-

ship of the dentures to each other and to the skull. Later Tweed found that these teeth could not always be upright but, in some instances, should have some labial or lingual inclination, depending upon the size of the Frankfort-mandibular plane angle. He originally determined the inclination of the mandibular incisors relative to the occlusal plane and later to the mandibular plane, but now determines it relative to the Frankfort plane as revealed in cephalometric roentgenograms.[9]

It might be well to digress at this time to discuss the care that must be exercised when using a single starting point or relationship as, for example, Tweed's inclination of the mandibular incisors. To determine the inclination of the mandibular incisor that he considers correct, Tweed suggests that when the Frankfort-mandibular angle is 25 degrees the long axis of the incisor should form a 90 degree angle with the mandibular plane which would, in turn, make this long axis have an inside angle of 65 degrees with respect to the Frankfort plane. Reasoning thus, he further suggests that a simple way to determine the correct crown position for the mandibular incisor for a given patient is to construct a line through the apex of the incisors that will intersect the Frankfort plane with an inside angle of 65 degrees. These teeth then may be correctly related to the mandible if they are rotated about their apex until their long axis coincides with this 65 degree angle line. The amount of movement labially or lingually of the incisor crown can be determined by measuring the distance between the incisal edge of the crown and this line. While this method may be satisfactory in many instances, there is one objection, namely, that it assumes the position of the mandible and the apex of the incisor to be in correct relationship to the rest of the skull, and also the apex of the incisor to be in correct relationship to the mandible. In a previous article[10] it was shown that the position of the mandibular incisor, even though unright, may have the apex well forward or back in relation to the bony chin point and, of course, the mandible may be overgrown, deficient, or mesially or distally malpositioned. Again, if the mandible overcloses, the inclination of the incisor relative to the Frankfort plane would be increased, while if the normal mandibular closure is not permitted because of interference, the Frankfort incisor angle will be decreased. In the latter instance, some of the correction of this incisor inclination would be obtained by a change in the vertical dimension, permitting desirable mandibular closure, rather than by a change in the inclination of the mandibular incisor teeth. Thus, it must be pointed out that what this method does is to correlate the angulation of the long axis of the mandibular incisors with respect to the Frankfort plane as determined by their apex position, but it does not indicate whether this apex is in a desirable position relative to the mandible or to the rest of the skull. If it is first determined that the mandible is not over- or under-developed or malpositioned and that the apex of the incisor is in correct position in the mandible, this method would be acceptable.

Most of the starting points or planes discussed so far deal primarily with the relation of the dentures to each other or to the skull and do not include

the relationship of other facial structures, although Simon expected his three plane method to be applied in relating any or all dentofacial structures to the cranium. Many other investigators have contributed anthropologic and cephalometric measurements, some of which are linear while others are angular, with a few of the latter being angles that certain structures make with reference to more or less established planes of the head. Examples of such normal standards are Hellman's polygons[11] and Downs cephalometric analysis[12] which is graphically represented by Adams and Vorhies utilizing Hellman's polygon.[13] Several years ago it was suggested that normal

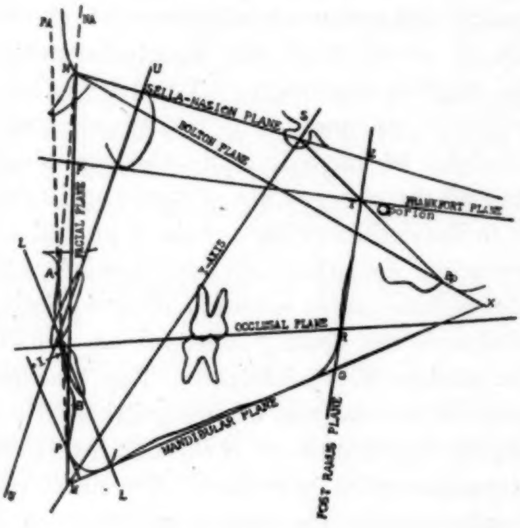

Fig. 1.

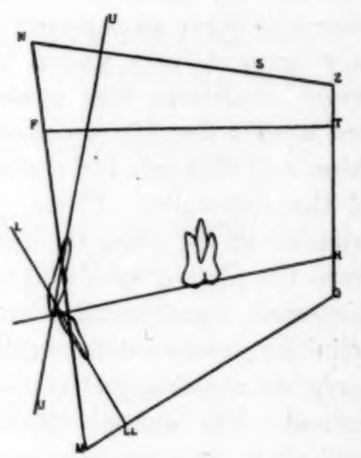

Fig. 2.

Fig. 1.—Tracing of a cephalometric profile roentgenogram with the planes, points, and lines used for a study of linear and angular measurements.

Fig. 2.—Illustrating a transparency consisting of two quadrilaterals selected from the various planes and lines illustrated in Fig. 1. One is based on the Frankfort plane and the other on the sella-nasion plane.

standard transparencies be placed over the cephalometric profile roentgenograms of a given patient for comparison.[14] These are based on linear and angular measurements accumulated in a facial growth study at the University of Iowa.* These transparencies included as a minimum two facial quadrilaterals, one based on the Frankfort and the other on the sella-nasion plane.[15] In addition, the position of either the second primary or first permanent molar and the position and inclination of the maxillary and mandibular incisors would be valuable inclusions (Figs. 1 and 2). These transparencies, to be most useful, should be available for male and female patients at the various age levels. Their use can reveal quickly whether the patient's facial structures are below, equal to, or above the average size, or whether the angular relationships of these structures are more acute, equal to, or more obtuse than the average. Without normal standards,

*A long-term research program begun in the spring of 1946 under the sponsorship of the College of Dentistry and the Iowa Child Welfare Research Station, University of Iowa. The study is directed by Dr. L. Bodine Higley and Dr. Howard V. Meredith.

diagnosis would be chaotic, since there would be no objective or scientific basis for comparison. It would be well to point out at this time an accepted fact, namely, that a zone of normal is always used rather than the exact average or mean.

What Is the Contribution of Diagnostic Aids to Diagnosis?—In considering diagnostic aids it should be emphasized first that the direct examination of the patient is the most important procedure in making a diagnosis. Often this direct examination results in a complete determination of the type and extent of the deformity and the etiologic factors responsible for its production. In such instances, any diagnostic aids procured, such as roentgenograms, photographs, or models, tend only to substantiate the direct diagnosis and otherwise serve as a record of the original condition. Of course, as records they serve a very useful and valuable purpose. All roentgenograms can reveal conditions that otherwise might be missed, while the cephalograms and models simplify measurements and the observation of structural relationships, and thus can add materially to the determination of the type and degree of the deformity. If the photographs, cephalograms, and models all are oriented in the same manner, they become more meaningful and, therefore, since the photographs and cephalograms are usually oriented on the Frankfort plane, gnathostatic casts or models are preferred. The transparent celluloid gnathometric charts designed for analysis of the gnathostatic casts serve as a quick method of judging deviations of the dentures from the normal. The normal standard transparencies previously described can be applied in like manner, to the cephalograms for their evaluation or interpretation should consume the least possible amount of time in order to be consistent with the basic idea that the diagnosis should be adequate but uninvolved; after all it does not treat the condition, even though it does indicate the therapy if needed.

What Is the Value of a Classification to Diagnosis?—For the novice a classification of dentofacial deformity or malocclusion of the teeth may suggest types of deformities usually encountered, which he could look for or expect to find. The classification also can group cases which have similar symptoms or characteristics and which demand a similar type of treatment. However, if the diagnosis terminates as soon as the condition can be classified, many important characteristics of the deformity may be overlooked. The use of a classification in this manner would limit or inhibit the determination of whether the discrepancy is one of size, form, or position of the various structures involved and exactly which of the structures is abnormal. For example, when a Class II, Division 1 deformity is mentioned, it may produce immediately a mental image of the typical deformity as described by Angle. However, Angle attributed the interdigitation of the posterior teeth in this class of deformity to a deficient mandible, whereas this same tooth relationship might occur from the following conditions:

1. The mandible and its superimposed dental arch may be normal in form and size, but upon closure they may be in a distal position with respect to the maxilla and cranium. This may be true because the condyle is up and back too far in the glenoid fossa, or the fossa is up and back too far in the skull, with the condyle in normal or distal position within it.

2. The mandible and its superimposed dental arch may be in distal relationship to the maxilla and cranium because the body or the ramus or both may be too short.

3. The mandibular teeth may be positioned distally on an otherwise normal mandible.

4. The gonial angle may be too acute, resulting in the menton's being closer to the condyle than usual which, in turn, would cause the mandible to appear short.

5. The maxillary posterior teeth may be positioned mesial to normal.

6. Combinations of two or more of these conditions may be present.

Thus, it is evident that pertinent information concerning such a variety of conditions responsible for a similar interdigitation of posterior teeth cannot be included in some classifications. The Simon classification in which any structure can be located with respect to his three planes is adequate, provided his norms can be accepted or others determined that will be. The Angle classification, regardless of its shortcomings, has retained its popularity because it is simple and graphic. In spite of limitations, classifications remain useful to facilitate description of deformities and summarize briefly the diagnostic findings.

What Is the Step-by-Step Procedure in Making a Diagnosis?—With the contribution of normal standards, diagnostic aids, and classifications agreed upon, it is possible to proceed with a rational diagnosis. Here, as previously indicated, the direct examination of the patient should be foremost. It is possible to be so busy acquiring diagnostic aids, which, incidentally, may never be referred to, that there is insufficient time or attention given to this direct examination. As the patient is examined, the various conditions found are either mentally or actually compared with the normal standards, and the conclusions drawn are recorded on his history chart. It seems appropriate and logical in the direct examination to consider first the child, next the head in relation to the body, then the face in relation to the rest of the head, next the jaws, then the oral cavity, and, finally, the teeth in relation to each other and to the rest of the head. Thus, we progress from the patient to the dental area, rather than possibly limiting our attention to the teeth and the immediate supporting tissues. The purpose of the examination, as discussed previously, is to determine: (1) Whether there is a deformity

and, if so, its type and severity; and (2) whether there are any etiologic factors present that may lead to a deformity or increase an existing one.

The actual step-by-step procedure in making the direct examination may be as follows:

1. Estimate the general health by considering whether the patient appears to be robust and vigorous or emaciated and listless. Take the height and weight, ask the age, and compare with a standard age, height, and weight chart. Watch for pernicious habits during the entire examination, as the parent or child may not be aware of them. The type of deformity which the habit has produced or may produce can be determined by observing the act and noting the direction of pressures. For example, if the tongue is only held between the teeth it will prevent eruption and result in open-bite, but if forced between the upper and lower teeth in swallowing the result will be protrusion, as well as open-bite.

2. Observe the facial relationships and proportions, first while the mandible is in the rest position and then in the closed position. While closed, a ruler can be used to measure the thirds of the face in the midline and a small transparent draftsman's triangle can be held beside the head to judge the profile in both the open and closed positions. When the base of the triangle coincides with the Frankfort plane by passing forward through the notch above the tragus of the ear to be flush with the orbital point, normally the right angle side should project down to pass through the corner of the lips and a short distance posterior to the gnathion, or bony point of the chin.

3. With the teeth still closed, note whether the lips are closed and unstrained or whether the teeth project through them. If closed, part the lips and check the overjet, overbite, mesiodistal and buccolingual intercusping or articulation and tooth inclinations, and whether the dentures appear well positioned over the basal bones. Now compare the midlines of the upper and lower dentures with each other and with the midline of the face. If the midline of the upper denture does not coincide with the midline of the face, the cause may be tooth malposition or deformity of the supporting structures. The same thing may cause the lower midline to be incorrect, but in addition it may be that certain teeth interfere as the dentures attempt to occlude, or that pathology of the temporomandibular joint causes the mandible to be deflected.

4. When deflection is found, test by having the patient slowly open his mouth. If the mandible swings back to and continues to open in the midline, it is tooth interference that has caused it to be deflected in the closed position. If the mandible swings even more off-center as the jaws continue to open, the cause is joint pathology of the ankylosis type. In ankylosis, the mandible always swings toward the side of the abnormal joint. Joint pathology of the tumor type or mechanical interference of a foreign object in the glenoid cavity also may produce deflection of the mandible upon closure, but toward

the side away from the affected joint. However, in this case the mandible will swing back to and continue to open in the midline, just as when tooth interference is the cause of deflection.

The most common tooth interference is that in which certain teeth in the maxillary arch are lingually positioned or this entire dental arch is too narrow for the opposing mandibular one. Fortunately, this narrowing of the maxillary arch is usually bilateral so that expanding it will eventually allow the mandible to close in the midline without interference of the teeth. Of course it is possible that the maxillary arch may be too wide, or the mandibular arch too wide or too narrow. In these cases it is necessary to decide which arch is more nearly normal, by comparison with such normal standards as Goldstein and Stanton's width of dental arches[16] or Pont's index,[17] and then consider the possibility of making the opposing arch conform. In testing to determine which teeth cause the interference, the patient should have the mandible guided, if necessary, into the midline, but closed just to initial contact with any opposing teeth. This will indicate immediately which teeth are producing the interference. Tooth interference also can cause the mandible to shift forward or backward abnormally in closing. This usually can be detected just after the teeth of the opposing arches come into contact. In normal closure from rest position, the chin point should go upward and slightly forward. If, on closure, it does not come forward as it goes upward, distal malposition may be suspected, but if it comes forward to any marked degree, mesial malposition is indicated. Condyle roentgenograms or profilograms may be used to determine more accurately whether there is mandibular malposition as explained in a former article.[14]

It is exceedingly important to observe the rest position of the mandible and the opening and closing movements as just discussed. The mandible may be in harmonious relationship to the superstructures of the skull when in the rest position, but considerable facial deformity may be produced upon closure, due either to tooth interference or to a perverted muscular habit. An example of the latter is the habitually incorrect closure in a 16-year-old boy who was referred for mandibular resection to reduce an apparently overgrown mandible. However, it was discovered that when the mandible was in the rest position, facial proportions were good, but upon closure the lower jaw became very prominent due to an acquired habit of thrusting the jaw forward. The forward abnormal closure may have been caused originally by a tooth interference which was no longer present, but the perverted muscular closing pattern was retained. The patient found that he could bite back in proper closure pattern when instructed and from that time on continued to do so with resulting good facial contour and a much improved functional occlusion.

5. Have the patient open the mouth and make a general survey of the oral health. Excessive caries and inflamed mucosa may indicate etiology of a systemic nature. It might seem logical to do this first or very early in the

examination, but it is placed here because when one starts the examination of the mouth it is sometimes difficult to return to the consideration of external factors especially important to the orthodontic diagnosis.

6. Count the teeth and, by referring to the normal standards, determine the dental age by considering whether the teeth present and their size (mesiodistal diameter in particular) and state of growth are as expected for the age of the patient and his present or predicted face and jaw size. Also consider whether the dental arches are symmetrical. Note the curve of Spee of the lower arch and the compensating curve of the upper dental arch, the size and position of the tongue, the condition of the hard and soft palates, the uvula, and the tonsils.

As many know, such an examination can, after some experience, be carried out in less time than it takes to tell, and so we see that much dentofacial deformity can be diagnosed by direct examination of the patient, but still it is often necessary to procure diagnostic aids to reveal certain conditions and to aid in determining the specific type and degree of the deformity.

Perhaps the question of extraction as it pertains to diagnosis should be given separate attention, since it has provoked considerable controversy. This disagreement would seem unwarranted if it is accepted as true that teeth can be markedly displaced from their normal positions on the mandible and maxilla, and that the size of the teeth is less affected by etiologic factors than that of the facial bones. If true, there are two valid reasons for extraction: the first, and obviously undisputable reason, is if there is a discrepancy in the size of the teeth in the opposing arches or if the teeth are too large for the present or predicted size of the facial bones; the second is if the teeth are displaced to such a degree that correct positioning would not be tolerated by the musculature or would be so time consuming as to be detrimental to the health of the tissues or to the psychological stability of the patient.

To determine whether the teeth are too large for the present or predicted size of the mandible and maxilla their mesiodistal widths are measured, and if they are found to be equal to or above the average sizes given in the standard tables and if the needed dental arch size likewise is determined to be much larger than the patient has, it must be decided by measurement whether the face could ever tolerate dental arches of the necessary proportions. If, upon measuring or estimating the size of the maxilla and mandible, it is found that they are large enough to accommodate the needed dental arch size, it then is necessary to decide whether the teeth can be conveniently placed in the desired positions and whether they will come into acceptable equilibrium with all the forces that will act upon them.

It was intended in the foregoing discussion to point out that diagnosis in orthodontics should mean systematically determining, by direct examination and with the help of good diagnostic aids and well-established normal standards, the presence of dental or facial deformity or any factor that might lead to such deformity.

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THE GONIAL ANGLE

A Survey

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THE present study is an attempt to evaluate the literature available on the gonial angle, a detail of the mandible which is important in orthodontic diagnosis. The gonial angle is related to planes and angles commonly used by the orthodontists as, for instance, the mandibular base line.[1-3] Since the angle, however, is influenced by the individual's age, race, sex, and physique, these factors have to be considered when the diagnosis and prognosis are made for a patient.

The gonial angle (also called the mandibular angle or the angle of the jaw) is the angle at which the lower border of the mandibular body meets the posterior border of the ramus. Besides being applied to the geometric angle, the point of intersection between these two sides, the term "gonial angle" is generally used to refer to this more or less protruding area of the mandible. The word "gonion," derived from the Greek word γωνία, meaning an angle, is an anthropometric term and is defined as "the lowest, most posterior, most lateral point of the angle."[4]

EVOLUTIONARY ASPECTS

The changes in the gonial angle during various evolutionary stages are associated with the evolution of the mandible and the changes in function to which this bone has been subjected.

Teeth and cartilaginous jaws were first differentiated in the primitive shark of the Devonian Era. At that time the jaws were nothing more than enlarged and modified gill arches. In the more complex jaws of the bony fish, amphibian, and primitive reptile there is no ascending ramus and, therefore, no angle.

Primitive mammallike reptiles show only a suggestion of the ramus which forms a very obtuse angle with the horizontal part of the mandible. As the mammallike reptiles became more advanced, the dentary increased greatly in size until, in mammals, it formed the entire mandible. Earlier, the dentary was the tooth-carrying bone among the several bones constituting the lower jaw.

At the same time a progressive enlargement of the ramus took place, which in mammals resulted in the formation of the temporomandibular joint. From the primitive mammal stage on, a distinct angle was present and in early primates this area developed into an angular process directed posteriorly. A similar process is seen in lemurs and has been named the *processus lemurinicus*.[5]

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In all the carnivora, rodents, and primates, both the ascending part and the angle, though varying, are well developed, and in the two largest anthropoid apes, the gorilla and the orangutan, the ramus is huge, although in its conformation and in the nearly semicircular outline of its angle region the mandible still resembles that of some of the large lower vertebrates more than it does that of man. But in the Old World, as well as in the New World monkeys, in the gibbons, and in the chimpanzees, both the ascending part and the angle of the mandible resemble the human form. The gorilloid angle region, that is, a broad angle portion with semicircular margin occurs occasionally also in the human jaw, "particularly it seems in the Eskimo and some American Indians."[16]

The mandible of some prehistoric human types, such as *Homo heidelbergensis,* is very similar to that of the early anthropoids. Since the days of our remote human ancestors, however, the entire mandible has undergone a reduction in size, the ramus has become narrower and "weaker," and the angle has increased (from 110 to 125 degrees).

The evolution of mandible and maxilla is closely related to an increase in the size of the cranium in combination with a reduction in the size of the face. Simultaneous with the enlargement of the cerebrum and the forward vaulting of the frontal part of the brain case, the facial structures changed their position relative to the cranial base from a distinct forward position to one located more posteriorly. This change is associated with a shortening in the depth and an increase in the height of the face. The jaws, which in most mammalian groups lie chiefly in front of the eyes, appear to swing downward and backward in primates until they are mostly behind and beneath the eyes. The shift from the horizontal to the vertical gait which takes place during the transition from the simian to the human stage also necessitates a reorganization of the muscles of the back and neck to maintain the equilibrium of the erect position.

Following the shift in posture, a change in direction and use of muscles, concerned with maintenance of head posture, has taken place. It does not seem unlikely that the directional change in muscle activity has played a role in the "modeling" of the mandible.

The decrease of the gonial angle from an almost horizontal line in the earlier reptiles to an almost right angle in the anthropoids may be interpreted as the effect of an intensification and differentiation of the chewing function. Conversely, the increase of the angle in the transition from anthropoids to man might be explained as a result of a decrease in muscle mass. It is a well-known fact that muscle traction exerts a considerable influence on the bony structure. In the early evolutionary stages, huge muscle forces were acting on the cranial bones, causing massive excrescences at their insertions, a condition which is characteristic for the skull of the male gorilla. Bony vestiges resulting from muscle activity are present in recent human skulls, especially in the nuchal, temporal, and gonial regions, and supply us with a rather clear impression of the amount of muscle mass which the individual possessed.

It may seem too presumptuous to attempt an explanation of the causative factors of evolution. One can only conclude that in the evaluation of the changes

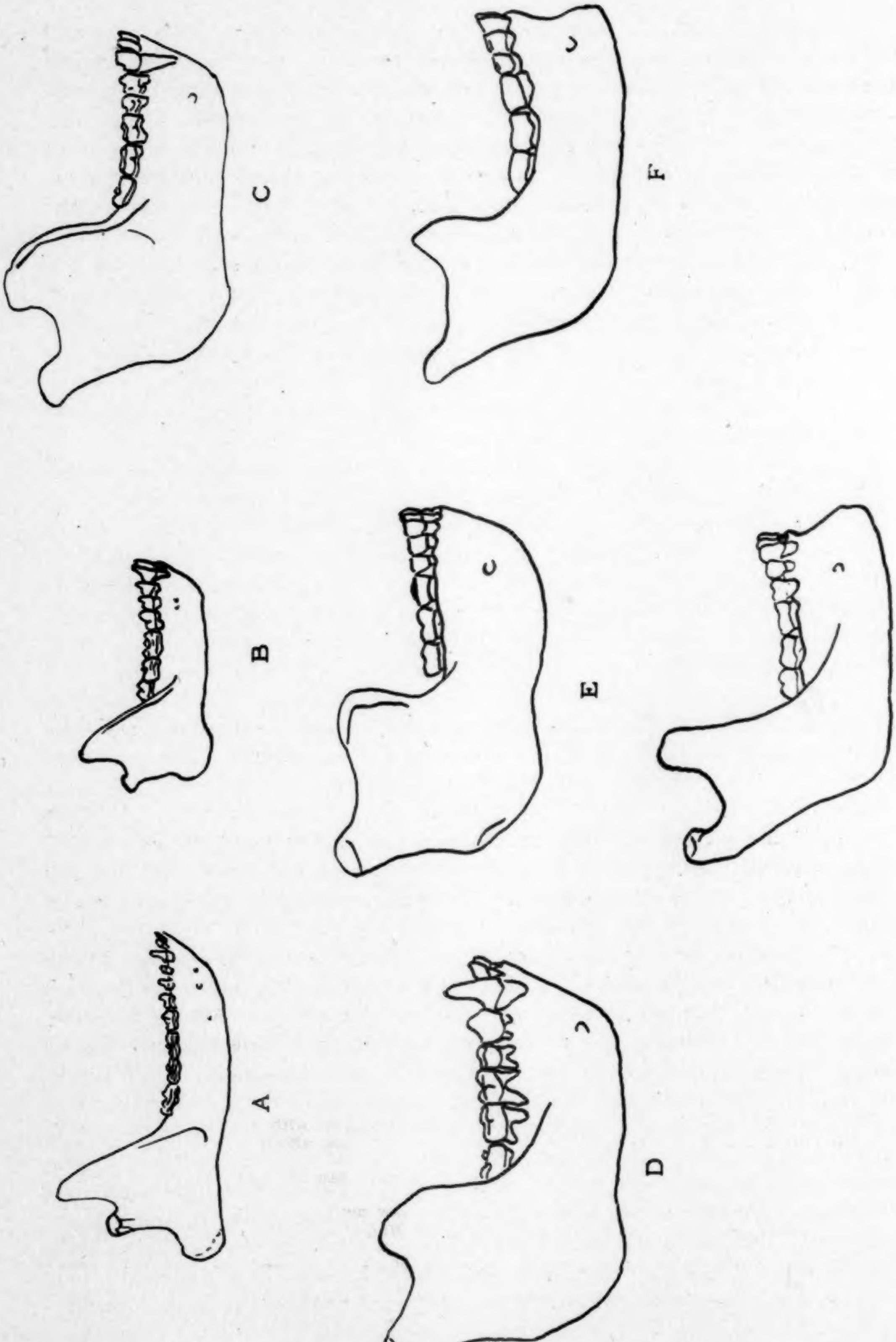

Fig. 1.—(*For legend, see opposite page.*)

in the mandibular angle during the past, the differentiation in function of jaws and muscles, the increase in height of the ramus, and the effects due to changes in posture and proportions of components of the head all must be taken into consideration (Fig. 1).

Broca's[7] invention of the goniometer established an accurate and uniform method of obtaining the desired measurements of the angle size in skull material and, with the exception of a few modifications, this instrument is still in use. The goniometer consists of a horizontal plane to which a movable plane is attached with a hinge. The mandible is placed on the horizontal plane, and the gonial angle is determined by adjusting the hinged plane so that it touches the posterior border of the ramus at two points, one near the condyle and one near the angle region.

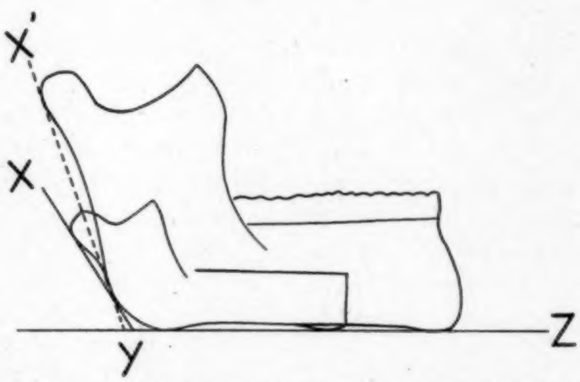

Fig. 2.—Superposition of the diagrammatic outline of an infantile and an adult mandible. The condylar angle *xyz* of the child decreases to *x'yz* of the adult. Note the stability of the contour of the conial angle. (From Weinmann and Sicher: Bone and Bones, The C. V. Mosby Company, publisher.)

This instrument, however, does not provide an ideal method of obtaining the size of the angle. It is certainly a well-defined and exact method, so that the records of various observers must be fairly comparable but, on the other hand, it does not provide us with a true picture of the gonial angle. It has been suggested[8] that the angle obtained by the Broca goniometer be called the "condylar angle," because it expresses more the relationship of the condylar region to the rest of the mandible than the true size of the gonial angle. The term "condylar angle" is somewhat misleading, since it makes us expect an angle with its points of intersection at the condyle. It is evident that the

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Fig. 1.—Evolution of the human mandible, side view.

A, Eocene lemuroid (*Notharctus osborni*). Jaw elongate, with primitive form of angle.

B, Parapithecus fraasi, Lower Oligocene (Egypt). Jaw shortened, angle beginning to expand.

C, Propliopithecus haeckeli, Lower Oligocene (Egypt). Jaw much shortened and deepened, angle expanded.

D, Sivapithecus, Miocene (Europe and India). Jaw much deepened.

E, Lowest human type, represented by jaw of *Homo heidelbergensis,* Pleistocene (Germany). Jaw very massive.

F, Low human type, represented by the jaw of an Australian native (*Homo sapiens australianus*). A bony chin developed, ascending ramus narrower.

G, Modern man. Bony chin protruding, ascending ramus weak.

(From Gregory: The Origin and Evolution of the Human Dentition, 1922, Williams & Wilkins Company, publisher.)

Broca angle may change considerably, even if the outline or the contour of the mandible in the angle region remains the same. Brodie's[9] x-ray examinations of children from 3 months to 8 years of age also seem to indicate that the change in contour of the angle proper is insignificant and that the growth changes in the condylar region are the main reason for the apparent decrease in angle size during this period (Fig. 2).

To suggest a method for measuring the gonial angle proper is not an easy task, however, as the rounded contour of the bone in this area does not provide us with any sharply defined points through which the side of the angle could be drawn, and Broca's method, despite its limitations, still must be considered as the most convenient way of recording the conditions in this area.

RACIAL VARIATIONS

Since anthropologic traits differ from one racial group to another, one may expect that the gonial angle exhibits changes also.

Much attention has been paid to this region by students of physical anthropology and racial anatomy. The gonial angle is obtuse in man, but this obtuseness varies, and may vary from 100 degrees to 148 degrees. There are strong indications that the angle reaches its highest mean values in the Caucasians, and prevalently nearly as high in the Negro; that it is low in the Melanesians and especially in the Polynesians; and that also it is markedly lower in the American Indians.[6]

TABLE I. GONIAL ANGLE

SKIN COLOR	MALE MEAN (DEGREES)	FEMALE MEAN (DEGREES)	FEMALE:MALE (MALE = 100)
White and related:			
Miscellaneous			
American white	123.5	128.0	103.4
Polynesian	118.0	123.5	104.7
Yellow browns:			
Chinese	122.0	127.0	
Eskimo	121.0	125.0	103.5
Outer Mongol	120.0	125.0	104.4
Potomac River Algonquin	118.5	123.5	104.5
Arkansas and Louisiana Mounds	118.5	122.0	103.0
Alaska Indians (collectively)	118.0	125.0	
Southwestern Alaska (Aleut, etc.)	117.0	122.5	104.9
Pueblo	115.5	120.5	104.2
Californian	114.0	118.0	103.1
Siouan	114.0	117.5	103.3
Floridian	112.5	117.5	104.2
Blacks:			
African and American (fullblood) Negro	120.5	126.0	104.6

From Aleš Hrdlička: Am. J. Phys. Anthropol. 27: 290, 293, 1940.

The first recorded measurements of the gonial angle were made by German and French investigators at the end of the nineteenth century. These measurements have not been taken in exactly the same way, and some of the series have been too small from a statistical point of view, or the selection has been inadequate.

One of the latest and most extensive studies has been done by Hrdlička[6] on 3,006 adult skulls of different races. All his data were obtained by means of the Broca goniometer (Table I). Between the lowest and highest mean values there is a difference of 10 degrees. Hrdlička admits that a great variability exists within each group, but nevertheless he considers that the gonial angle shows definite racial differences.

Martin,[4] in his "Lehrbuch der Anthropologie," doubted that such differences exist; Morant[10] in his study published in 1936, found that only the mean value of the gonial angle in Australian aborigines shows a significant difference from that of other races. The mean values of sixty-six racial groups all lie between 120 degrees and 125.3 degrees, with the exception of that of the Australians, which was somewhat lower, being 117 degrees. The variability within each group is considerable, and, in the opinion of Morant, there is no significant racial difference in angle size.

In connection with the study of the size of the gonial angle as a racial trait, a sexual difference has been found (Table I). Usually the mean angle is 3 to 5 degrees larger in the female than in the male. This appears to hold true for all human groups, primitive as well as "civilized,"[6, 11, 12] and the relation of the angle values between the two sexes is remarkably uniform.

For these sexual differences, however, there is a great deal of overlapping, so that in individual cases the gonial angle is of limited value for the differentiation of sexes when dealing with skulls.[6, 13] All that can be said is that an angle below 118 degrees points toward a male and an angle above 128 degrees toward a female, but the exceptions are numerous.

These sexual differences in the size of the gonial angle may be explained by differences in the dimensions of the mandible. According to Hrdlička, the female mandible of all races has a wider gonial angle, but is smaller in all dimensions. It deviates most from the male mandible in symphyseal height and especially in height of the ramus. In the female a relatively short ramus is combined with a wider gonial angle. Also, in this connection we have to consider the amount of muscle mass which is greater in males than in females.

Attempts have been made to relate the differences in size of the gonial angle to other anthropologic measurements. Kieffer,[14] in 1902, found that the angle was, on an average, considerably larger in brachycephalic Germans than in the dolichocephalic Italians and Negroes. Hrdlička, on the other hand, finds no correlation between skull type and gonial angle. The same angle size has been found in the brachycephalic Aleuts and the dolichocephalic Californian Indians.

Individuals with long and narrow faces (leptoprosopic) appear to have a more obtuse angle than individuals with short and broad faces (chamaeprosopic) as suggested by Kieffer. Draper[15] related the form of the mandible to the body build as a whole. He found a heavier mandible and a more square gonial angle in the pyknic type than in the asthenic type. Sheldon[16] also confirms that mesomorphic individuals have heavier and squarer mandibles than individuals with less muscle mass.

Cleaver[17] has measured breadth of the ramus in relation to the gonial angle and found a negative coefficient of correlation. The broad solid ramus apparently belongs to the more vertical type of mandible, whereas the slender ramus accompanies the sloping type.

In attempting to explain differences in the gonial angle between races, Hellman[18] has compared the various facial dimensions in Australians, Hindus, and Hungarian Whites. The short face of the Australian is prognathic, the mandible is well developed in height and length, and the gonial angle is very small. In the orthognathic face of Hindu and White, the mandible is relatively smaller, and the gonial angle is obtuse. Hellman has considered these three types only, but it seems clear enough that the gonial angle is dependent on the facial dimensions and varies from race to race.

AGE CHANGES

It is a well-established fact that the gonial angle (as measured with the Broca goniometer) changes during a lifetime. The traditional idea that the angle begins as a straight line in the newborn child and ends as the same in the aged has been rejected long since.[7, 14] At birth the gonial angle is rather obtuse, it decreases in obtuseness throughout life, and enlarges anew with old age. This development has been attributed to the construction and destruction of the dentition.

Age changes within the Caucasian race have been studied by various orthodontists, and it is accepted by most that there is a wide range of variation within each age group. By collecting the data previously given by Engel, Welcher, Ruge, Sappey, Renard, Topinard, Debierre, and others, Izard,[19] in 1927, was able to establish the following average of variability:

150 to 135 degrees, at birth.
140 to 130 degrees, when first dentition is finished.
130 to 120 degrees, up to the time of the eruption of the twelve-year molars.
120 to 150 degrees, in old age.

Herkelmann[20] seems to be the only investigator to have dealt extensively with the condition in the fetus. His publication (1935) reveals the very interesting facts that the gonial angle in the embryo is of the same size as that of adults and during the intrauterine period becomes more obtuse, reaching its climax at birth. The growth of the cranium and the skull base is more accelerated than the growth of the jaws during this time, and Herkelmann considers the flattening of the angle to be due to a more rapid increase in the depth of the upper part of the face compared to the growth in length of the mandible. This means that the increase in distance between the body of the mandible and the glenoid fossae should cause the ramus to incline increasingly backward. After birth the angle becomes more acute again because the mandible increases more in length than does the upper part of the face in depth.

Stunz[21] has measured the gonial angle in infants from birth to 2 years of age and has been interested in the modifying influence of function. In this two-year period an average decrease of 15 degrees is found, the angle

changing from 141 degrees at birth to 126 degrees at 2 years, a considerable decrease in such a short period of time. Herkelmann also found a great decrease (10 degrees) in the first two years of life. According to Stunz, the greatest decrease (of 10 degrees) took place during the first five months and the angle changed very slightly (4 degrees) during the succeeding nineteen months. In her opinion, this considerable change during the first period is due to functional influences. The infant is developing feeding habits and learning excursions of the mandible; at 5 months the action of the muscles and ligaments is established.

Dunn[22] also considers the stimulus due to sucking and feeding to have a great influence on the shape of the mandible. By sucking, the mandible assumes a more anterior position and an increase in growth occurs in the front region as well as in the ramus, accompanied by a change in the angle. Stuntz's and Dunn's explanations seem to be rather insufficient and vague, and there is no evidence that the function of the muscles, taking part in the sucking and chewing processes, has more influence on the modeling of the jaws in this period than have the developmental forces.

Hellman[23] has investigated angle changes in older age groups. His material consists of ancient American Indian skulls from Arizona, and the absolute measurements cannot be compared with those previously mentioned in the Caucasian race, but they represent a very homogeneous group and a complete age range from infancy to senility. He measured the gonial angle, compared it with other measurements of the mandible, and found that the size of the angle is dependent upon the proportion of the height of the ramus to the length of the body of the mandible. The shorter the ramus, the more obtuse the angle (Table II).

TABLE II. STAGES OF DEVELOPMENT, SHOWING RELATIONSHIP OF RAMUS HEIGHT AND BODY LENGTH OF MANDIBLE TO THE GONIAL ANGLE

STAGES	AVERAGE RAMUS HEIGHT (MM.)	AVERAGE MANDIBULAR LENGTH (MM.)	RELATIVE HEIGHT OF RAMUS TO LENGTH OF MANDIBLE (PER CENT)	AVERAGE MANDIBULAR ANGLE (DEGREES)
I	28.00	51.40	54.47	138.19
II	35.46	58.82	60.29	132.46
III	44.00	79.30	55.49	124.25
IV	53.50	85.44	62.61	122.16
V	60.41	91.92	65.72	117.39
VI	62.40	93.74	66.56	115.65
VII	61.75	91.59	67.42	116.80

The stages in development of the dentition, indicated by the Roman numerals I to VII, are defined by Hellman* as follows:

Stage I: The period of early infancy (before the deciduous dentition is completed).
Stage II: The period of late infancy (when the deciduous dentition is completed).
Stage III: The period of childhood (the first permanent molars are erupting).
Stage IV: The period of pubescence (the second permanent molars are erupting).
Stage V: The period of adulthood (the third permanent molars are erupting).
Stage VI: The period of old age (the occlusal surfaces of the molars are worn off to the extent of obliterating the pattern of grooves).
Stage VII: The period of senility (most, or all, teeth are lost or at least half of the crowns are worn off).

*From Milo Hellman: J. D. Res. 9: 183, 197, 1929.

During growth, the ramus increases more in height than the mandibular body increases in length, and the angle becomes more and more acute. Before the deciduous dentition is in full function (Stage I) the ramus height is only slightly more than one-half the body length; in old age it is more than two-thirds (Stage VI).

The only drop in relative increase occurs during childhood (Stage III) when the first molar is erupting. At this time the growth of the mandibular body is very much accelerated.

Concurrent with the relative increase in ramus height, a decrease in the size of the gonial angle occurs with increasing age (Table II).

In Hellman's opinion the increase in the height of the ramus and the entire face is partly due to the stimulating influence of the erupting teeth. Many do not agree, and exclude any influence of the teeth in their evaluation of the growth of the jaws and the size of the gonial angle.[8, 24, 25]

Advanced age and loss of tooth substance and teeth usually are considered to be associated with a marked increase in the size of the gonial angle.

Among the earlier investigators, Kieffer alone maintained that such an enlargement does not take place just because an individual grows older, but occurs only with the complete loss of teeth. This has been substantiated by Hellman and also by Keen.[26] Keen, comparing observations taken from three different age groups (6 to 21 years, 25 to 45 years, and 50 to 76 years) of individuals provided with sufficient teeth to ensure the height of the bite, was able to prove statistically that there is no increase of the gonial angle with increasing age. On the contrary, a decrease was observed from the youngest to the oldest group.

With loss of teeth, however, the angle increases in size. By comparing the 25-to-45-year group with teeth and a group of edentulous individuals of all ages (17 to 86 years), Keen found a significant increase of 5 degrees with loss of teeth. The mandible assumes a new relationship to the maxilla which may be characterized as a decrease in height of the face. This loss of intermaxillary support due to the absence of teeth permits the masseter and internal pterygoid muscles to exert an unopposed pull on the mandible, thereby flattening out the gonial angle.

According to Lönberg,[27] this adaptability of the mandible to the edentulous condition depends on the age of the individual at the time the teeth are lost. By comparing groups with and without teeth at two different age levels (24 and 72 years), these changes occur in the younger group only. In old persons the modifiability of the mandible is less and the angle does not change after a total loss of teeth.

The cross-sectional studies have indicated certain tendencies in the age changes of the gonial angle, although to some extent these are obscured by the great variations observed within each age group. The gonial angle increases in size from the early embryo (130 degrees) to the time of birth (140 to 145 degrees) and from then on decreases as the individual ages. The rate of this decrease is not constant, however, the greatest change occurring before the age of 6 years (12 to 16 degrees), and from this age to adulthood the decrease is

about one-half as much as in the preceding period. From adulthood to old age a slight decrease is taking place (2 to 3 degrees), and only by loss of teeth may the angle become more obtuse again (2 to 7 degrees).

THE GONIAL ANGLE IN ORTHODONTIC DIAGNOSIS

As may be seen from the preceding, the gonial angle in man is subjected to several conditioning terms, such as race, age, and sex, which in varying degrees seem to exert a modifying influence on its size. A question naturally must come into our minds at this point: Can our knowledge of the variations of the angle be of any help in our evaluation of orthodontic cases? Or rather: Are we now able to decide by measuring a patient's gonial angle that this angle is abnormal for this particular patient and that consequently an abnormality or malformation of his facial structure is present? The answer must be that it is of importance to know approximately the condition which we would expect to find in that special type of patient we have in our chair, but that the evaluation of the gonial angle is no short cut to orthodontic diagnosis. A thoroughgoing appraisal of the skeletal configuration in the face and skull is still needed, more because the effect of a seemingly abnormal gonial angle may be counteracted by modifying conditions elsewhere in the face, resulting in a fairly harmonious appearance and a functionally satisfactory occlusion. Still, certain facial deformities are known to be associated with anomalous values of the gonial angle. In micrognathism and in acromegaly the angle may measure about 20 degrees above what is considered to be normal. In micrognathism the growth in the condyle has been arrested and the ramus is abnormally short. The body of the mandible appears to be bent down in the region just in front of the angle, resulting in a retrusion of the chin and an open-bite.[28, 29] In acromegaly the mandible is overdeveloped in all dimensions, causing a protrusion of the mandible and an increase in facial height.

On the whole, a certain relationship seems to exist between facial height, ramus height, and the size of the gonial angle.[29] By means of the Frankfort-mandibular plane angle, Johnson[3] has shown that the size of the gonial angle is dependent upon the proportion between the height of the face and the ramus height. Anomalous values of the gonial angle seem to occur when a malproportion exists between these parts. With a relative increase of the facial height the gonial angle becomes more obtuse, as may be seen in many cases of open-bite. In some of these cases Izard[29] found that during adolescence a progressive opening of the bite occurred, simultaneously with an enlargement of the gonial angle (135 degrees to 140 degrees to 150 degrees). In cases of deep overbite there is a reduction of facial height, or rather of dental height, the ramus is comparatively well developed,[30, 31] and the gonial angle shows a tendency to become more acute.

The vertical disharmonies are often combined with a sagittal discrepancy in the relationship of the jaws. The size of the gonial angle, however, seems to be relatively independent of variations in anteroposterior direction and varies according to the aforementioned vertical deviations which generally accompany them.

Björk,[31] in his monograph "The Face in Profile," indicates that a mesial occlusion may be associated with a large gonial angle, as well as with a small one. It is, therefore, erroneous to believe that an obtuse gonial angle alone could cause a protrusion of the mandible. Björk has shown also that the sagittal disharmonies are caused mainly by a disproportion in the length of the jaws and/or by a malposition between them, dependent on the length and shape of the skull base. The changes in the gonial angle can be considered only as a secondary effect of the previously mentioned discrepancies.

In an extensive study on sagittal disharmonies, Björk found, however, that on the average the gonial angle was increased a few degrees when a mesial occlusion was present, and no deviation was found when a distal occlusion existed.[31]

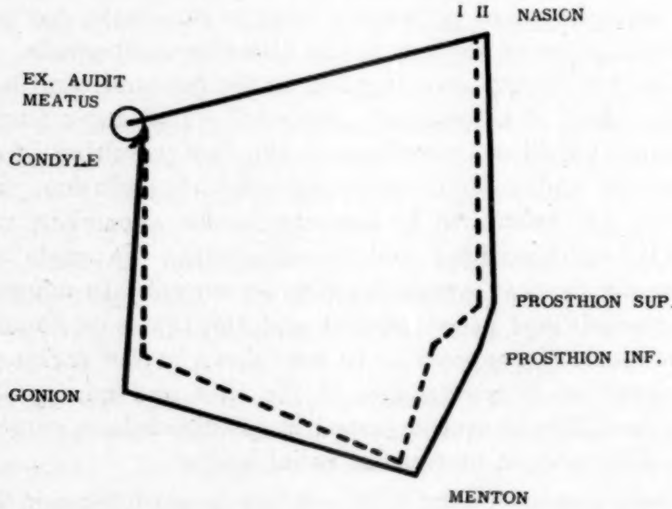

Fig. 3.—Diagrammatic presentation of facial profiles of two Class II, Division 1 cases of malocclusion. (From Hellman: *Int. J. Orthodontia,* November, 1927.)

Hellman[18] has measured the facial dimensions in individual cases of malocclusion and compared them. Two different cases of Class II, Division 1 deviate in an interesting way as shown in his diagram representing the facial relationships (Fig. 3).

In Case 1 the upper face is almost normal in position and dimension and the distal relationship between the jaws is caused by an underdevelopment of the mandible. The ramus height and the facial height are reduced and the gonial angle shows no marked deviation from the average. In Case 2 the distal relationship between the jaws is caused by a protrusion of the maxilla. The facial height is reduced and the angle is more acute.

Individual cases of Class III were examined in the same way (Fig. 4). In Case 1 the mesial relationship between the jaws is mainly due to an overdevelopment of the mandible, especially of ramus height. The facial height is normal, and the angle is below the average. In Case 2 the facial height is

reduced due to an underdevelopment of the upper part of the face. The mandible is in normal position, but the ramus is very short, while the gonial angle is normal.

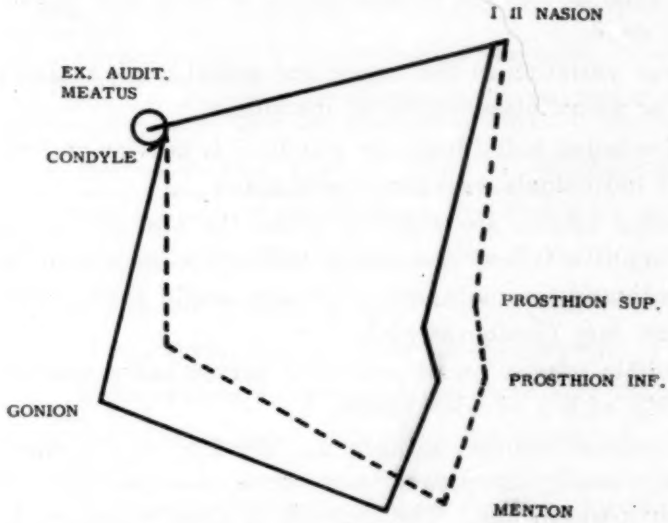

Fig. 4.—Diagrammatic presentation of facial profiles of two Class III cases of malocclusion. (From Hellman: *Int. J. Orthodontia,* November, 1927.)

As has been shown by Hellman and Björk, many variations of the gonial angle are possible within the same class of malocclusion. Once more it is demonstrated to us that no single trait, be it the molar relationship or the size of the gonial angle, is sufficient for an exact classification and diagnosis of facial and dental malformations. The gonial angle is only a detail, but it reflects the coordination and proportion between the different parts that constitute the unity of the human face.

SUMMARY

A survey of the literature reveals diverse interpretations of the term "gonial angle."

The term has been used in referring to the posterior inferior angle region of the mandible (Brodie), as well as to the angle formed by a tangent to the lower border of the mandible and a tangent touching the posterior border of the ramus at two points, one at the condyle and one at the angle region (Broca).

Although the latter is more properly an indication for the relationship of the condyle to the mandibular body than a measurement of the gonial angle itself, it is the one commonly recorded and also the one considered in this survey.

1. During evolution the gonial angle has decreased from an almost straight line in early reptiles to almost a right angle in anthropoids. It has become obtuse again in the transition from anthropoid to man. These changes in the gonial angle are associated with altered function of the jaws and masticatory muscles, as well as with the changes in posture and in the differential rates of growth of the components of the head.

2. The gonial angle in man may vary from 100 degrees to 148 degrees. Its mean angle is highest in Caucasians, nearly as high in Chinese, Eskimos, and Negroes, and lowest in early Caucasians, Australian, and American Indians.

3. In all racial groups the mean angle in females is 3 degrees to 5 degrees higher than in males.

4. The large variation in the size of the gonial angle makes this trait useless for racial or sexual classification of mandibles.

5. In well-muscled individuals the mandible is heavier and the gonial angle smaller than in individuals with less muscle mass.

6. Conflicting results are reported when the size of the gonial angle is related to the cephalic index. According to Kieffer, individuals with short and broad faces (chamaeprosopic) have a smaller angle than individuals with a long and narrow face (leptoprosopic).

7. A mandible with a broad and solid ramus has a smaller gonial angle than a mandible with a slender ramus.

8. Cross-sectional studies indicate an increase in the size of the gonial angle from early embryonic stages to the time of birth and a continuous decrease from birth to old age. The decrease is greatest before 6 years of age; thereafter until adult life the rate of decrease is about one-half as great; and from maturity to old age it is only a few degrees. A complete loss of teeth may reverse the usual age changes and the gonial angle becomes more obtuse again.

9. A longitudinal study (3 months to 8 years) by Brodie indicates that the contour of the mandible in the region of the angle remains the same during this period.

10. The size of the gonial angle is associated with the proportion between facial height and ramus height. With a relatively greater facial height the angle is more obtuse (for example, open-bite); conversely, with a relatively smaller facial height it is more acute (for example, deep overbite).

11. The size of the gonial angle is rather independent of variations in facial development seen in the sagittal plane.

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WIDTHS OF THE DENTAL ARCHES AT THE PERMANENT FIRST MOLARS IN CHILDREN 9 YEARS OF AGE

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THIS investigation deals with selected transverse diameters of the maxillary and mandibular dental arches. It is delimited in scope to one odontic region (that of the permanent first molars), one ethnogeographic group (North American white children), and one chronologic age (9 postnatal years). Major aims are:

1. To review the various terminal landmarks and methodologic procedures that have been used for determining width of the dental arches in the region of the permanent first molars.

2. To survey the North American research literature from the standpoint of findings for dental arch widths at the permanent first molars on orthodontically unselected white children 8.5 to 9.5 years of age.

3. To present experimental results on the reliability of two measures of dental arch width: (a) minimum transverse distance between the lingual surfaces of the permanent first molars and (b) maximum rectilinear breadth between the buccal surfaces of the permanent first molars.

4. To describe widths of the maxillary and mandibular dental arches in the region of the permanent first molars on original samples of white boys and girls 9 years of age. Minimum and maximum bimolar diameters for each arch are depicted by central tendency and dispersion statistics.

5. To investigate, in each sex group, relationships (a) between minimum bimolar diameter and maximum bimolar in both of the arches and (b) between maxillary arch width and mandibular arch width for interlingual and interbuccal data.

METHODS OF MEASUREMENT

The terminal points employed in measuring the transverse distance between the permanent first molars have varied widely in different investigations. They are grouped for review into three categories: (1) buccal surface landmarks, (2) lingual surface landmarks, and (3) landmarks in the zone between the buccal and lingual tooth surfaces.

Buccal Landmarks.—Lancet,[1] Northcroft,[2] and Woods[3] determined the maximum rectilinear distance between the right and left buccal surfaces of the permanent first molars; that is, these workers measured from the lateralmost extension of the crown on one side of the arch to a corresponding point on the opposite side of the same arch. Schwarz[4] measured "from the center

of the buccal surface," Spiller[5] "between the external cervical margins," Smyth and Young[6] "at the neck of the tooth, at the base of the disto-buccal cusp," and Williams[7] "from the buccal groove of the right first molar to the buccal groove of the left first molar."

Lingual Landmarks.—Northcroft[2] and Stephens and Campion[8] obtained the minimum straight-line distance between the left and right lingual surfaces of the permanent first molars; that is, they measured from the innermost projection of the crown on one side of an arch to the complementary landmark on the other side. Brawley and Sedwick[9] secured the smallest measurement obtainable "between the lingual surfaces . . . at the gingival margins." Channing and Wissler[10] took the transverse diameter "at the gum-line," using "the lingual fissure as the point from which to measure." Cohen[11] measured "from the mesial-lingual cusp . . . on one side of the arch to the mesial-lingual cusp . . . on the opposite side of the same arch."

Intermediate Landmarks.—Schwarz[12] derived a "central width" by averaging one measurement taken between the centers of the mesial (anterior) alveolar margins of the permanent first molars, and a second measurement taken between the centers of the distal (posterior) alveolar margins. Stanton, Fish, and Ashley-Montagu[13] reproduced "the bucco-lingual outline of the form of the teeth at the gingival margin, together with . . . the mesio-distal contact-diameters of the teeth." They located each bimolar terminus as "the point of intersection of the central mesio-distal and bucco-lingual diameters." Broadbent [14] and Willett[15] determined the transverse rectilinear distance between the permanent first molars "from central pit to central pit" and Sillman[16] used points adjacent to "the distal groove of the second deciduous molar."

While casts have constituted the commonest source of data on dental arch width, measurements have been taken "directly from the mouth,"[6, 9] on "orthographically projected maps and artificial stone models,"[17, 18] and on frontal roentgenograms corrected for distortion with the aid of a Wylie compensator.[3]

PREVIOUS FINDINGS

North American publications pertaining to odontology include numerous reports on dental arch widths in the region of the permanent first molars. However, many of these reports supply no quantitative data, give measurements only for pathologic and/or orthodontically treated arches,[8, 12, 14, 19] or, as has been noted earlier by Goldstein and Stanton,[18] present records from study "of single or a very few individuals."

In systematizing the previous findings for dental arch widths at age 8.5 to 9.5 years, the procedure will be first to assemble the measurements "of single or a very few individuals" and then to review the studies utilizing samples of not less than ten children.

Data for Individual Children.—Spiller[5] reported an arch width measurement taken in 1905 on the maxillary dental cast of a boy 8.5 years of age.

The arch had not been subjected to orthodontic treatment, nor was any need for treatment indicated. Its permanent first bimolar width, "measured between the external cervical margins," was 55.6 mm.

Measurements of the dental arches were obtained by Willett[15] on a child 8.6 years of age. Orthodontic treatment was limited to spreading the mandibular arch. The distance between the central pits of the permanent maxillary first molars (breath of the untreated arch) was 45.7 mm.

Schwarz[4] measured the cast of an orthodontically normal upper dental arch taken on "a boy of Swiss nationality" aged 9 years. Bimolar diameter, using as termini "the center of the buccal surface of both maxillary first molars," was 54.0 mm.

Maxillary and mandibular dental arch measurements were reported by Sillman[16] representing transverse distances between the permanent first molars from points adjacent to "the distal groove of the second deciduous molar." The subjects at 9 years of age were four healthy white children. "At no time did any of them receive appliance therapy." Maxillary widths were 43.2 mm. and 40.4 mm. for the two boys, 41.0 mm. and 40.9 mm. for the two girls. Corresponding mandibular widths were 39.0 mm., 34.9 mm., 34.4 mm., and 36.2 mm., respectively.

Following an expression of professional interest in "the natural growth of the width . . . of the dental arches," Lancet[1] reported measurements of the transverse distances between the upper and lower permanent first molars on two individuals 9 and 9.5 years of age depicting "developmental conditions" uninfluenced by orthodontic treatment. The bimolar width utilized was that between the "outermost areas" of the buccal surfaces. For the individual measured at 9 years, the maxillary width was 57.3 mm. and the mandibular width, 54.0 mm.; the subject aged 9.5 years had corresponding upper and lower cast widths of 58.0 mm. and 55.8 mm.

Wallace[20] measured dental casts obtained on a single subject with normal dental arches. At 9.25 years of age, the widths between the permanent first molars were 33.8 mm. for the maxillary cast and 32.3 mm. for the mandibular cast.

On a single female subject with "normal occlusion," Chapman[21] measured a permanent first intermolar width for the maxillary arch. At age 9.4 years, the distance between "the central fossae at the base of the lingual cusps" was 47.0 mm.

Data for Groups of Children.—In 1908 Channing and Wissler[10] published a major paper on width of the maxillary arch in the region of the permanent first molars. They studied the minimum bimolar distance "at the gum-line," taking "the lingual fissure as a point from which to measure." At 9 years of age casts were measured for eighty school children and twenty-seven feeble-minded individuals. The means obtained were 33.1 mm. on the school children and 33.8 mm. on the feeble-minded children.

Alley[17] analyzed maxillary arch measurements on forty-seven children between 8 and 9 years of age studied in the New York University Division of Child Research. The measurements were made on "orthographically projected maps," using the landmarks (centroids) previously defined.[13] This series of bicentroid widths at the permanent maxillary first molars gave a mean of 43.9 mm. and a standard deviation of 1.9 mm.

Utilizing the same method as Alley (and probably some of the same subjects), Goldstein and Stanton[18] studied the upper and lower arch widths of thirty-seven children 9 years of age representing the general run of middle class white children in New York City. The maxillary bimolar measurements gave a mean of 44.0 mm. and a standard deviation of 2.1 mm., the mandibular measurements a mean of 43.2 mm. and a standard deviation of 1.7 mm. Further subdivision of the data according to sex afforded maxillary means of 44.4 mm. for the twenty-one boys and 43.6 mm. for the sixteen girls. Corresponding mandibular means were 43.4 mm. and 42.8 mm. for boys and girls, respectively. The range of individual differences for each sex and dental arch was as follows: 39.1 mm. to 47.8 mm. for boys, upper arch; 40.8 mm. to 47.2 mm. for girls, upper arch; 39.3 mm. to 47.4 mm. for boys, lower arch; and 39.8 mm. to 44.9 mm. for girls, lower arch.

Brawley and Sedwick[9] measured the width "between the lingual surfaces of the maxillary first molars at the gingival margins" on fifty-nine children 9 years of age considered to constitute "a fairly representative cross section of school children." Measurements were taken directly from the mouth. The obtained means were 32.6 mm. for the total sample, 32.6 mm. for the forty-six boys, and 32.5 mm. for the thirteen girls. Corresponding standard deviations were 2.7 mm., 2.7 mm., and 3.6 mm., respectively.

Dental arch width was investigated by Cohen[11] on twenty-eight children 9 years of age constituting "a representative cross-section of the population of the city of Minneapolis . . . all had fairly normally developed dental arches." Upper and lower casts were measured "from the mesial-lingual cusp of the first permanent molar on one side of the arch to the mesial-lingual cusp of the first permanent molar on the opposite side of the same arch. . . . Each measurement was taken independently by three different operators." For the upper arch, the means were 40.2 mm. for fifteen boys and 40.4 mm. for thirteen girls. The corresponding standard deviations were 2.5 mm. and 2.8 mm. For the lower arch, male and female means were 34.8 mm. and 37.0 mm., male and female standard deviations were 2.1 mm. and 3.1 mm.

Woods[3] studied the transverse distance between the widest points of the permanent first molar crowns (wherever found) on fourteen 9-year-old children of each sex. Most of the children had normal occlusion; two had untreated Class II and Class III malocclusions, and one ("a case of treated Class I malocclusion") had received orthodontic therapy. The data were obtained from frontal roentgenograms, corrections having been made for x-ray distortion by means of a cephalometric compensator. On the upper arch, the means were 55.7 mm. and 54.3 mm. for boys and girls, respectively.

On the lower arch, the mean for boys was less by 0.9 mm. and that for girls was less by 0.5 mm. Individual records ranged from 50.5 mm. to 58.0 mm. in the upper arch, and from 49.0 mm. to 57.5 mm. in the lower arch.

THE ORIGINAL DATA

Description of Sample.—Original data for arch width were amassed from ninety-four white children (forty-four boys and fifty girls) 9 years of age. All the children resided in or near Iowa City, Iowa, and were enrolled in the Facial Growth Study (a long-term research program begun at the State University of Iowa in the spring of 1946).* Enrollment in the study was based upon willingness to participate, and probability of continuing residence in the Iowa City area; it was not related to dental conditions or orthodontic needs.

The subjects were American-born children of northwest European ancestry (that is, descendants of immigrants from the British Isles, Germany, Scandinavia, and the Netherlands). They were predominantly of above average socioeconomic status; information on occupation of the fathers showed that 40 per cent of them were professional men, while the remainder held managerial, commercial, or skilled-trade positions.

Source Materials.—Maxillary and mandibular dental casts were secured on each of the ninety-four subjects. These casts were made from alginate hydrocolloid impressions obtained in all instances by Dr. L. B. Higley. Special care was taken with the impressions and the casts in order to maximize their research usefulness. Evidence that the source materials did closely approximate morphologically valid reproductions was derived by measuring minimum width of the maxillary arch at the permanent first molars (a) directly in the mouth and (b) on the dental cast. Averages on five different children measured several times each way showed no systematic variation.

Collection Procedures.—Two arch widths were determined on each cast: (1) The minimum straight-line distance between the right and left lingual surfaces of the permanent first molars, and (2) the maximum transverse diameter between the buccal surfaces of the right and left permanent first molars.

All measuring was done with sliding vernier calipers checked for accuracy against a standard millimeter scale. Separate records were obtained by each of us, the two sets of records being strictly independent.

Each dimension, in turn, was determined on the entire series of casts. That is, the minimum bimolar diameter was taken on all the maxillary casts, then the maximum diameter on all the maxillary casts, and so forth. Measurements were made to the nearest one-tenth millimeter.

The data are highly homogeneous with respect to age. In all instances the impressions were taken on the child's ninth birthday or within a week of this date.

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*This program has been maintained under the joint sponsorship of the College of Dentistry and the Iowa Child Welfare Research Station, with Professors L. Bodine Higley and Howard V. Meredith serving as co-directors.

FINDINGS ON RELIABILITY OF MEASUREMENTS

How dependable are the measurements of arch width obtained in this study? Was error in measurement reduced to an extent that the records made by the two measurers showed close agreement? Methodologically, it is obligatory to consider this problem before proceeding to analyze the data for findings on widths of the arches and relationships between arch widths.

Reliability was studied by two statistical procedures. The one procedure consisted of applying the Pearson product-moment method of correlation to each of the eight series of paired values.* Table I presents the reliability coefficients obtained for each arch-sex-dimension subgroup. It will be seen that all of the coefficients are high, those for the interlingual data being slightly higher than those for the interbuccal data.

TABLE I. RELIABILITY COEFFICIENTS FOR TWO MEASURES OF DENTAL ARCH WIDTH TAKEN AT THE LEVEL OF THE PERMANENT FIRST MOLARS ON MAXILLARY AND MANDIBULAR CASTS FOR WHITE CHILDREN 9 YEARS OF AGE

	MAXILLARY ARCH				MANDIBULAR ARCH			
	MALES		FEMALES		MALES		FEMALES	
DIMENSION	N*	r†	N	r	N	r	N	r
Minimum width	44	0.997	50	0.994	44	0.996	50	0.995
Maximum width	44	0.991	50	0.989	44	0.991	50	0.988

*N = number of subjects.
†r = product - moment correlation coefficient.

The second procedure was that of computing the standard deviation of distributions of differences derived from the paired values. The algebraic difference was secured between every pair of records from the two measurers. These differences were tabulated in two distributions, one each for the minimum and maximum first bimolar widths.† The standard deviations of the distributions were found to be 0.12 mm. in the case of the 188 interlingual differences and 0.16 mm. for the 188 interbuccal differences.

Summarizing for reliability, the independent measurements of arch width taken by each of us have been shown to be highly consistent; that is, measuring errors were satisfactorily minimized.

FINDINGS ON DENTAL ARCH SIZE

The arch width values employed after this point are averages of the paired records which constitute the basic data. In other words, each value utilized in arriving at the findings of this and the succeeding sections is the mean of two separate determinations, one by each of us.

Central Tendency.—The series of composite values for each of the eight arch-sex-dimension subgroups yields the means displayed in Table II. Major

*The two separate records obtained for a given child, a specific dental arch, and a particular transverse diameter are referred to as a pair of values.

†On finding that the magnitude of chance error for a given width was equivalent in boys and girls, and on casts of the upper and lower arches, it was possible to combine (1) the four arch-sex subgroups pertaining to minimum width, and (2) the four arch-sex subgroups pertaining to maximum width.

TABLE II. MEANS FOR TWO MEASURES OF DENTAL ARCH WIDTH TAKEN AT THE LEVEL OF THE PERMANENT FIRST MOLARS ON MAXILLARY AND MANDIBULAR CASTS FOR WHITE CHILDREN 9 YEARS OF AGE

	MAXILLARY ARCH				MANDIBULAR ARCH			
	MALES		FEMALES		MALES		FEMALES	
DIMENSION	N	MEAN*	N	MEAN*	N	MEAN*	N	MEAN*
Minimum width (mm.)	44	34.4	50	32.0	44	33.1	50	30.6
Maximum width (mm.)	44	56.5	50	53.4	44	53.7	50	50.4

*The standard errors of the means vary from 0.24 mm. to 0.39 mm. Only those for the minimum and maximum width of the upper arch on males exceed 0.30 mm.

findings from this table typifying 9-year-old white children of northwest European ancestry and above average socioeconomic status are as follows:

1. The minimum transverse diameter between the lingual surfaces of the permanent first molars, characterizing the two arches and both sexes together, approximates 32.5 mm., or 1.28 inches.
2. The maximum transverse diameter between the buccal surfaces of the permanent first molars, again characterizing the two arches and both sexes together, approximates 53.5 mm., or 2.11 inches.
3. In each bimolar dimension, the mandibular arch is narrower than the maxillary arch. On the average, the maxillary arch exceeds the mandibular arch in interbuccal diameter by 2.8 mm. (boys) and 3.0 mm. (girls), in interlingual distance by 1.3 mm. (boys) and 1.4 mm. (girls).
4. For both bimolar dimensions, the average boy has a wider dental arch than the average girl. Quantitatively, the interbuccal distance is less for girls than for boys by 3.1 mm. (upper arch) and 3.3 mm. (lower arch); the interlingual diameter is less for girls than for boys by 2.4 mm. (upper arch) and 2.5 mm. (lower arch).

Dispersion.—To know the "average" size of a dental arch trait is valuable, but not sufficient. As Hrdlicka[22] emphasized as early as 1916, ". . . there is no such thing . . . as one single normal dental arch; . . . in every race . . . we find a variety of arches which must be considered as normal." We turn, then, to a description of the dispersion, or variation, within our eight subgroups.

TABLE III. VALUES REPRESENTING EIGHT DISTRIBUTIONS OF INDIVIDUAL DIFFERENCES PERTAINING TO TWO MEASURES OF ARCH WIDTH TAKEN AT THE LEVEL OF THE PERMANENT FIRST MOLARS ON DENTAL CASTS FOR WHITE CHILDREN 9 YEARS OF AGE

			PERCENTILES				
ARCH-SEX GROUP		MINIMUM	10	25	75	90	MAXIMUM
				Minimum width			
Upper arch:	Males	29.1	30.7	33.0	36.0	37.4	41.3
	Females	28.7	29.9	30.8	33.0	34.2	36.1
Lower arch:	Males	28.7	30.4	32.0	34.5	35.5	36.6
	Females	26.9	28.7	29.4	31.8	32.9	34.5
				Maximum width			
Upper arch:	Males	51.4	52.6	55.1	58.3	59.4	64.6
	Females	49.6	51.2	52.0	54.4	55.9	57.6
Lower arch:	Males	48.9	51.1	52.3	55.4	56.2	57.8
	Females	45.7	48.2	49.1	51.4	52.8	54.3

Table III gives the minimum value, the maximum value, and four selected percentiles for each subgroup in turn. It will suffice to illustrate (a) the direct findings this table yields and (b) its normative usefulness. All the illustrative statements refer, of course, to white children 9 years of age and to breadths of the arches at the permanent first molars.

1. One-half the boys studied had minimum maxillary arch widths between 33.0 mm. (twenty-fifth percentile) and 36.0 mm. (seventy-fifth percentile). In the same trait, one-half the girls clustered between 30.8 mm. and 33.0 mm. (Note that 33.0 mm. represents the lower boundary of the central 50 per cent for boys and the upper boundary of the central 50 per cent for girls.)

2. For 80 per cent of the boys studied, minimum mandibular arch width was between 30.4 mm. (tenth percentile) and 35.5 mm. (ninetieth percentile). Corresponding figures encompassing 80 per cent of the girls are 28.7 mm. and 32.9 mm. (Note that 10 per cent of the girls had minimum mandibular widths below 28.7 mm., but that none of the boys had an arch narrower than 28.7 mm.)

3. The total scatter for boys with respect to maximum width of the maxillary arch is describable in the following terms: its lowest one-fourth extends from 51.4 mm. to 55.1 mm., its central one-half lies between 55.1 mm. and 58.3 mm., and its highest one-fourth extends from 58.3 mm. to 64.6 mm. Passing to the maximum width of the mandibular arch, the narrowest one-fourth of the boys fall within the bounds of 48.9 mm. and 52.3 mm., the widest one-fourth between the limits 55.4 mm. and 57.8 mm.

4. Suppose that the casts of three girls 9 years of age have been measured for maximum width of the maxillary arch with results of 50.5 mm., 53.3 mm., and 55.0 mm. On referring to the normative figures of Table III, it is seen that the first girl has a narrow upper arch (that is, her record lies near the lower limit of the normal continuum), the second girl has an upper arch of average width, and the third girl has a moderately wide upper arch. Assume further that records for maximum width of the mandibular arch on the same three girls are 49.7 mm., 48.6 mm., and 54.0 mm. Table III shows that the first girl has a lower arch of average width, the second girl a moderately narrow lower arch, and the third girl a wide lower arch.

Another medium for describing variability is the standard deviation. This statistic epitomizes the dispersion of a distribution by a single value. For minimum transverse diameter between the permanent first molars, the obtained standard deviations are 2.5 mm. (boys) and 1.7 mm. (girls) in the upper arch, and 1.8 mm. and 1.7 mm. for boys and girls, respectively, in the lower arch. Listed in the same order, the subsample standard deviations for maximum transverse diameter between the permanent first molars are 2.6 mm., 1.8 mm., 2.0 mm., and 1.8 mm.

FINDINGS ON DENTAL ARCH RELATIONSHIPS

Relation Between the Two Widths.—Since erupted permanent first molar teeth differ in (a) buccolingual diameter and (b) direction of mesiodistal di-

ameter with respect to the midsagittal plane, it would not be expected that the interlingual and interbuccal distances of a given dental arch correlate perfectly. The question arises as to how high is the association between these two measures of arch width.

Information on this question was sought through application of the Pearson product-moment method of correlation to the four appropriate subdivisions of the data. For the maxillary arch, the obtained coefficients are 0.86 for the forty-four boys and 0.79 for the fifty girls. Corresponding coefficients expressing the relationship between minimum and maximum width between the permanent first molars of the lower arch are 0.87 for boys and 0.83 for girls.

Relation Between the Two Arches.—The final problem investigated was the association between a particular transverse dimension on the maxillary cast and the comparable dimension on the mandibular cast. Again, the statistic computed was the Pearson $\underline{r}$. Minimum width at the permanent upper first molars in relation to minimum width at the permanent lower first molars yields coefficients of 0.71 for the forty-four boys and 0.73 for the fifty girls. The complementary results for maximum width are $\underline{r} = 0.76$ and $\underline{r} = 0.79$ for boys and girls, respectively. It is of interest that Smyth and Young,[6] using a somewhat wider age group,* obtained a coefficient of $\underline{r} = 0.86$ from correlating maximum maxillary width between the permanent first molars with maximum mandibular width between the permanent first molars. The subjects were "a random group" of eighty-seven boys 9 to 10 years of age drawn from the public schools of London, England.

SUMMARY

This article reports a study of dental arch width in the region of the permanent first molars on children 9 years of age. Its opening sections (1) survey the different methods of determining arch width that have been employed, and (2) review previous findings on 9-year-old white children contained in the North American research literature.

Succeeding sections of the paper present the results from analyses of original data accumulated on ninety-four Iowa children of northwest European ancestry and above average socioeconomic status. The topics investigated are (1) reliability of arch width measurements, (2) central tendency and variability of arch width distributions for boys and girls 9 years of age, and (3) arch width interrelationships at the age of 9 years. Selected findings are:

1. Both the minimum transverse distance between the lingual surfaces of the permanent first molars and the maximum rectilinear breadth between the buccal surfaces of the permanent first molars can be obtained through the medium of dental casts with high morphologic validity and reliability.

*For a discussion of the influence of increased variability on the size of the correlation coefficient see Guilford.[23]

2. Generalizing for the two arches and both sexes, minimum interlingual width at the permanent first molars on the 9-year-old children studied averages 32.5 mm., or 1.28 inches. The corresponding over-all mean for maximum interbuccal width at the permanent first molars is 53.5 mm., or 2.11 inches.

3. On the average, the maxillary arch is wider than the mandibular arch by approximately 1.3 mm. in interlingual diameter at the permanent first molars and 2.9 mm. in interbuccal diameter at the permanent first molars. The average boy has a wider dental arch than the average girl by about 2.4 mm. in interlingual diameter and 3.2 mm. in interbuccal diameter.

4. There is neither a high relationship between the interlingual and interbuccal measurements of a given dental arch nor between the maxillary and mandibular measurements for a comparable diameter. The correlations found on homogeneous age-sex groups are of the order $\overline{r} = 0.85$ for interlingual widths in relation to complementary interbuccal widths, and $\overline{r} = 0.75$ for upper arch widths in relation to corresponding lower arch widths.

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Editorial

Discussion at Orthodontic Meetings

DISCUSSION of scientific papers is a lost art in present-day orthodontics. Time was when the discussion following the presentation of a paper frequently brought forth more interesting information than the paper itself. With the acceleration of orthodontic research and the increase in volume of work accomplished in the field, discussion has been gradually eliminated from the scientific meetings of orthodontic groups.

Another, and perhaps equally important, reason why discussions as a feature of orthodontic meetings have fallen into disfavor is the fact that with the growth of orthodontic art and science, intelligent discussion of original contributions could no longer be undertaken by members of the audience without adequate preparation. It is no longer sufficient for the discusser to give his opinion. He also has to document his remarks and to give references to his sources of information. This requires that the discusser be provided with a copy of the paper he will be called upon to discuss. Those who have had any experience in arranging programs for orthodontic meetings know how difficult it is to obtain papers for publication even after they have been read, much less to obtain papers in advance of the meeting.

A third reason why extemporaneous discussion has been relegated to limbo may be found in the abuse of this privilege by some who, when given the opportunity to discuss a paper, took advantage of this opportunity to ride their own hobby horses and spoke about subjects which had nothing to do with the topic under discussion.

With the foregoing in mind, I would like to suggest that chairmen of scientific programs for meetings of orthodontics consider having open discussion periods. This would induce self-participation by the audience and would add interest to scientific meetings. Perhaps a question and answer period would be one method of meeting the present lack of color of many of our orthodontic gatherings.

J. A. S.

In Memoriam

DWIGHT ANDERSON

DWIGHT ANDERSON, former Director of Public Relations for the Medical Society of the State of New York, and the former Executive Secretary of that Society, died at the Jackson Memorial Hospital, Miami, Fla., Sunday, Dec. 20, 1953.

Mr. Anderson was Director of Public Relations for the American Association of Orthodontists from 1939 to 1942. He conducted public relations for many professional health groups during his lifetime.

Mr. Anderson was 71 years old at the time of his death.

H. C. P.

EDWARD J. COPPING

1895-1953

THE members of the Northeastern Society of Orthodontists were recently informed of the untimely death of their fellow member and colleague, Dr. Edward J. Copping of Chevy Chase, Md., on May 15, 1953.

He was always one of our genial friends, quiet and unassuming, but profoundly dependable, and a faithful, ardent student who always gave his best services to his patients.

His keen interest in his profession and in community affairs were always uppermost in his thoughts.

Dr. Copping was born in Liverpool, England, April 24, 1895, and came to this country at 6 years of age. He graduated from George Washington Dental School about 1915 and later served in the United States Army Dental Corps as a Lieutenant at Walter Reed Hospital. He first practiced in Takoma Park, D. C., and then became associated with Dr. Maurice J. Conley at 1801 I Street, N.W., Washington, D. C.

His many activities in dental, civic, and religious affairs are shown by his memberships in the District of Columbia Dental Society, the American Dental Association, the Northeastern Society of Orthodontists, the Takoma Park Lions Club, Manor Club, Citizens Association, and the Horticultural Society.

He served for two terms as president of the Takoma Elementary Home and School Association and also was a vestryman of the Trinity Episcopal Church.

He is survived by his wife, Mrs. Virginia Powell Copping, three sons, one brother, and one sister.

Inasmuch as the dental profession and his home town have lost a trustworthy friend and a most enthusiastic worker in various civic, religious, and dental fields, be it hereby

Resolved that these resolutions be spread upon our minutes and that a copy be sent to the members of his family as a token of our esteem for Dr. Copping and of our wish to express to them our deep sorrow and heartfelt condolences at this time of bereavement.

LOWRIE J. PORTER, CHAIRMAN
NECROLOGY COMMITTEE
NORTHEASTERN SOCIETY OF ORTHODONTISTS.

FREDERICK C. ALLEN
1890-1953

ON SUNDAY, July 26, 1953, at Ogunquit, Maine, one of New England's best-known orthodontists, Dr. Frederick C. Allen, died at the age of 63. He was a graduate of Tufts Dental College in 1911 and was a past president of the Tufts Dental Alumni Association.

After graduation, he associated himself with Dr. Victor Hugo Jackson of New York and spent seven years in the practice of orthodontics under Dr. Jackson's preceptorship. Following a short period of service in World War I as a First Lieutenant in the Dental Corps, Dr. Allen established his orthodontic practice in Brookline, Mass. Ten years later he moved to Boston in association with Dr. William Gilpatric, where he remained until Dr. Gilpatric's death. He then became associated with Dr. Frank Delabarre, whose practice he carried on after Dr. Delabarre's death up to the time of his own passing.

Dr. Allen was prominent in Delta Sigma Delta fraternity, having served for twenty-eight years as the Deputy Supreme Grand Master of the undergraduate chapter at Tufts Dental College. This devotion to a job which called for sacrifice of time and energy on behalf of the students of dentistry was typical of his unselfishness and willingness to help others. These characteristics, along with his cheery manner and happy disposition, accounted for his popularity with his colleagues and patients.

Dr. Allen is survived by his wife, Mrs. Moss Logan Allen; a daughter, Mrs. Ralph Aubin; and three grandchildren.

Whereas the dental profession has lost a fine friend and an ardent worker for our chosen field of service, be it therefore

RESOLVED that this expression of bereavement be spread upon our minutes and that a copy be sent to the family of our esteemed confrere, Dr. Allen, for it is our desire to share this sorrow with them and we wish to convey to them our sincere feeling of sympathy.

LOWRIE J. PORTER, CHAIRMAN
NECROLOGY COMMITTEE
NORTHEASTERN SOCIETY OF ORTHODONTISTS.

Department of Orthodontic Abstracts and Reviews

Edited by

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Differences Between the Facial Skeletal Pattern of Class III Malocclusion and Normal Occlusion: By Richard T. Sanborn, D.D.S., M.S., University of Illinois, Chicago, Ill.

The purpose of this investigation was to determine if there were significant differences between adult facial skeletal patterns in Class III malocclusion and normal occlusion.

Class III material consisted of cephalometric roentgenograms of forty-two individuals, twenty-six males and sixteen females. The control material consisted of cephalometric roentgenograms of thirty-five individuals, twenty-six males and nine females.

Angular relationships of anatomic points and planes were appraised. The anterior cranial base, ramus, and body of the mandible were measured linearly. On the average the Class III facial skeletal pattern showed a middle face deficiency and a more prognathic mandible than the normal, resulting in a concave profile which was the most striking feature of the Class III deformity. The ramus of the mandible in the Class III group formed a more acute angle with the anterior cranial base and upper face than in the normal, which had the effect of positioning point gonion further forward. The gonial angle was more obtuse and the lower border of the mandible more steeply inclined.

No significant difference was found between the two samples in the mean length of the ramus from articulare to gonion, nor the mean length of the body of the mandible from gonion to gnathion. There were no significant differences in the angular relationships between the horizontal planes of the upper face, viz., anterior cranial base, Frankfort, palatal, and occlusal planes.

The study tended to show that the Class III deformity was due to a combination of factors involving malformation and malrelation of the parts that go to make up the dentofacial complex. The skeletal patterns of Class III malocclusion and normal occlusion differed in many respects, not only in the denture area, but also in their interrelated parts.

The Application of Frontal Laminagraphy to the Study of Nasopharyngeal Development in Normal and Cleft Palate Children: By J. Daniel Subtelny, B.S., D.D.S., University of Illinois, Chicago, Ill.

Numerous investigators have observed an abnormally wide nasopharynx in cleft palate patients. The nasopharyngeal anatomic relationships have extensive implications regarding craniofacial growth, mode of therapy, and speech potentiality. Therefore, it appears mandatory that some objective measure of the width of the nasopharynx be obtained. The pterygoid processes of the sphenoid bone, radiographically visualized, would render satisfactory lateral nasopharyngeal measurements.

Frontal laminagraphy offers a method whereby deep areas may be measured accurately. It is based upon synchronized film and target movements in op-

posite directions. The selected plane, remaining stationary, registers clearly. Structures not within the desired lamina are blurred and displaced.

In this study the sedated child is horizontally positioned on the table top facing the target. A special head holder maintains Frankfort horizontal plane during exposure. The measurement from table top to ear post combined with an instrumentally determined measurement from the external auditory meatus to pterygomaxillary fissure establishes the depth of desired visualization.

The instrument devised to predetermine the location of the pterygomaxillary fissure consists of a steel wire supporting an acrylic pyramidal button, which is placed intraorally in the recess posterior to the maxillary tuberosity. The wire proceeds forward to curve around the corner of the mouth and extends, extraorally, backward parallel to the Frankfort horizontal plane. Two adjacent tubes soldered onto the end of the wire complete a symmetrical U shape. Two wires pass freely within the tubes, permitting anteroposterior adjustment. A perpendicular loop soldered to these wires and supplied with an adjustable acrylic post permits vertical adjustment to position the post within the meatus. Readings consist of determining the distance from the end of the tubes (which are in line with the pterygomaxillary fissure) and the meatus.

To date, this study includes 100 children under 3 years of age: sixty with unoperated cleft palates and forty with normal palates.

The Relation of Speech Defects and Malocclusion: Murray Bernstein, B.S., D.M.D., M.S., Tufts College Dental School Department of Orthodontics, Boston, Mass.

It is stated by speech authorities that malocclusion is responsible for certain defects. The information presented appears vague and not too well substantiated, and a review of the literature shows an apparent lack of scientifically based investigation. A study seemed indicated to give the orthodontist information on the relation of malocclusions and speech defects.

The study was conducted with the following objectives in mind:

1. To determine if any significant difference exists in the number of malocclusions found in a group of children with speech defects and in a similar group with normal speech.
2. To determine if there is any relation between malocclusion and speech defects and, if so,
   (a) to determine if any specific type of defect is related to any specific type of malocclusion.
   (b) to determine if the severity of the speech defect is related to the severity of the malocclusion.

The Lynn Public School System of Lynn, Mass., was selected for obtaining the material used in this study. In this school system all the children are examined and tested for speech defects by competent speech therapists.

The criteria for malocclusion were based on Angle's classifications. A separate group consisting of open-bite was included.

The experimental group of 437 speech defect children was examined for malocclusion. A control group of 446 children with normal speech was also examined for malocclusion.

After the initial examination it was possible to divide the experimental group into two; one group of children with speech defects and no malocclusion, and one group with speech defects and malocclusion. The latter group was further investigated by means of oriented lateral head x-rays in the Margolis Cephalostat and by speech recordings.

The data were subjected to statistical analysis and the following conclusions were drawn:

1. Children with speech defects do not have a greater amount of malocclusion than children without speech defects.

2. Speech defects are not related to malocclusion generally except in the classification of open-bite.

3. In the classification of open-bite there is a strong relationship to lisping.

4. In open-bite, the severity of the lisp does not vary with the amount the bite is open or with the amount of overjet, or overbite. More data are necessary for a more definite conclusion.

Some Observations Upon the Environment of the Incisors: By R. Ernest Rix, F.D.S., M.R.C.S. Reprinted (with deletions) from *D. Record* **73**: 427-441, April, 1953.

During mastication one sees a balanced play of activity between the lips and cheeks on the outside of the arches and of the tongue lying within. Without this interplay, food could not be guided and held precisely in position while the teeth shear and crush it. The teeth and alveolar bone are subjected to the same guiding forces which control the food. The position of food is the result of momentary muscular activity. The position of our teeth reflects, within certain limits, the result of a summation of external and internal muscular activity over a period of years of growth.

Mastication provides stresses upon the dento-alveolar structures which serve to keep the radial positions (i.e. buccolingual and labiolingual) of upper and lower teeth closely related.

While mastication provides peak periods of stress calculated to foster well-knit radial relations another muscular stress, that of swallowing, is being exerted intermittently, and continues to be exerted at other than mealtimes as well. For better or for worse, swallowing adds its contribution to the moulding forces created by mastication.

By the time the permanent dentition starts to arrive the teeth are normally brought into occlusion during the act of swallowing. With the teeth in occlusion a rigid walled cavity is produced. The external musculature is comparatively inactive while the tongue, with the aid of the mylohyoids, exerts its thrust in the form of a peristaltic wave against the walls of the cavity to force food back through the isthmus of the fauces. A beneficial centrifugal thrust to the dento-alveolar structures is provided in this way which is not counterbalanced by external musculature in a state of considerable tension, and there is no element introduced to upset the good radial relations of the teeth which mastication fosters.

In children with normal behaviour during swallowing one tends to find fairly ample arches with the crowns of the upper and lower incisors and cheek teeth well-adjusted radially to each other. It would hold true even in the absence of normal antero-posterior cheek teeth relations. There are slight variations too in the basic set of the mandible to the maxilla in the antero-posterior plane, which children have who possess what we would regard as a normal dentition. It would, however, become increasingly difficult for the musculature to maintain good radial relations as the fundamental set of the two jaws to one another showed increasing variations in the antero-posterior plane.

I want to describe a mode of swallowing which produces stresses unlike those of the normal way of swallowing. They cut right across the moulding

forces of mastication and of normal swallowing in so far as they hinder rather than foster good radial relations.

It is a mode of swallowing which as far as the behaviour of the tongue, lips, and cheeks is concerned is very like the behaviour of the breast-feeding infant. The infant has a relatively large tongue. It fills the mouth into which the dento-alveolar structures have not yet arisen. It meets the cheeks and lips across the meagre gum pads and a point to note is that it is the lower lip rather than the upper which makes a broad contact with the tongue anteriorly.

In breast feeding the tongue is moved forward, grooved longitudinally and consequently narrowed slightly as it is applied to the lower half of the areola of the breast, the upper half of which is in contact with the unyielding palate. The mandible is at first depressed. The bulk of the lower lip remains in apposition with the ventral surface of the tongue, but its everted margin lies against the breast to form a seal with it and to help support it. The margin of the upper lip completes the anterior seal. To express milk the shape of the tongue is altered. The longitudinal groove changes at the front as the anterior margin of the tongue curls up to initiate a wave of pressure on the areola, a mechanism which Gwynne Evans has described and shown in his films. The mandible is elevated at the same time and the lower gum pad gives support from below to the upward movement of the front of the tongue. With the progressive shifting of the longitudinal grooving of the tongue from below backwards the milk is forced to the back of the mouth to be squirted with the aid of the mylohyoids through the isthmus of the fauces.

As the infant passes out of the period of breast feeding the dento-alveolar structures are slowly rising to intervene between the tongue and its previous soft tissue boundaries. In response to the changing quality of the diet the behaviour of the tongue, the lips and the cheeks becomes more specialised. The ingestion of foods entails more than the primitive compression of the areola against a palate.

Now let us suppose that at the age of, say, six years the deepening alveolar bone, carrying deciduous incisors in the process of being shed and the permanent incisors on the point of eruption, is gradually moving more into a muscular field that retains characteristics of the suckling stage. In preparing to swallow, the child first depresses the mandible from its rest position. The tongue moves forwards and is narrowed. There is an accompanying drawing in of the lower lip against the ventral surface of the tongue. Despite the indrawing of the lower lip the margins of upper and lower lips are kept in contact by an eversion of the margin of the lower lip. The fleeting movements are reminiscent of the process of preparing to encircle the areola of the breast. The upper lip is pursed rather than drawn tightly back across the surface of the upper deciduous incisors. The lower lip exhibits more tension than the upper. The mentalis is tightened as well as the orbicularis oris. In fact the lower lip forms a taut sling with the aid of mimetic muscles. The preliminary drawing in of the lower lip is seen in some children to be an exaggerated upward scooping action as though the child were having difficulty in dislodging crumbs from the lower labial and buccal sulcus. This preliminary stage rapidly changes to a positive pressure stage which squeezes prepared food or saliva collected on the anterior half of the dorsum of the tongue back through the isthmus of the fauces. The parallel between the infant's suckling process persists in this positive pressure stage. While still being held forward the tongue presses up against the palate in the region of the on-coming permanent incisors. The thrust is accompanied by a tensing of the mylohyoids and an elevation of the mandible from the depressed position assumed in the preparatory stage. It is not elevated enough, however, to bring the teeth into oc-

clusion. The lower lip is momentarily drawn back still more firmly against the ventral surface of the tongue, thus forming a resistant wall to aid the thrust of the anterior part of the tongue against the palate in the region of the expected incisors. The emerging permanent lower incisors are repeatedly subjected to pressure from the taut lower lip while the mass of the tongue has moved upwards and forwards away from their lingual sides. With insufficient countervailing pressure on their lingual sides the lower incisors do not move adequately forwards. There is a tendency for them to be retroclined, to be flattened or to be imbricated because they are prevented from moving forwards into a smooth curve. Some months later the erupting upper incisors are prevented from becoming closely applied to the lower incisors by the repeated thrust of the tongue. We have thus a situation where the mechanism of swallowing brings forces to bear in the incisor regions which run counter to the moulding forces of mastication and normal swallowing, and which promote a discrepancy in the position of the crowns of upper and lower incisors in the antero-posterior plane. This incisor picture is a common cause of complaint which they in Great Britain have to deal with and it is often, though not invariably, brought about by this particular type of behaviour. The incisor crowns show the typical error in the antero-posterior plane, and with this antero-posterior error goes the adaptive adjustment in occlusal level which enables the lower incisors to maintain occlusal contact. An exaggerated occlusal curve of the lower arch accompanies these cases. Another feature to notice is the way in which antero-posterior relations become progressively worse the nearer the teeth are to the front of the mouth where the tongue and lower lip are exerting their adverse pressures. Although the "back wash" of these pressures has petered out by the time they have reached the first permanent molars, even these molars are sometimes affected so that they too show an error in the antero-posterior plane. The normal occlusal adjustments of the first molars which are expected during the period of six to thirteen years might well be affected. Forward migration of the lower first molars would be prevented. The shedding of the lower deciduous molars, normally providing that little extra room for the usual mesial adjustment of the 6's would merely provide opportunities for the premolars to move distally in relation to the lower first molars. In the upper arch the check to forward migration of the first permanent molars would be removed for anterior teeth are being urged forward. In this way the abnormal strains operating in the front of the mouth in a proportion of these abnormal swallowers can sometimes so affect the whole dentition that it can be labelled a Class II occlusion. Ballard has already shown that a Class II coronal relationship can be superimposed on a Class I and Class III apical relationship.

There is another dental defect which affects a proportion of children in this group. Instead of an excessive overbite accompanying the increased overjet they show varying degrees of anterior open bite. These children not only exhibit a suckling behaviour of the tongue during swallowing, but the posture of the tongue remains infantile throughout. There is a continued contact between the tongue and the lower lip. The front of the tongue does not retreat within the dental arches. It remains forward with its ventral surface in contact with the lower lip forming a pitched roof over the lower incisors. This contact can be easily maintained while the mandible moves during changes of facial expression. During smiling, when the lip seal is broken, the tongue can be seen in contact with the lower lip. Sometimes even during speech there is a reluctance to forsake the tongue-lower lip contact and a characteristic change is produced in the sound of sibilants. Lower incisors erupting under these conditions are impeded. When the upper incisors appear a little later they too are

sometimes impeded in their occlusal rise, but on the whole the more forward they are guided by the suckling tongue action the less are they impeded.

In essence therefore these anterior open bite cases retain for too long an added characteristic of infant behaviour. Fortunately as the years go by it tends to be forsaken. A proportion of anterior open bites gradually improves without treatment.

Still another defect not infrequently crops up in association with these tendencies towards incisor errors in the antero-posterior and vertical planes. It is the crossed bite resulting from a relatively narrow upper arch. Crossed bites are seen where swallowing retains suckling characteristics. The bulk of the tongue is brought forwards during swallowing. The cheeks are put in tension. The continuous muscular band stretching right round the dental arches from one pterygomandibular raphe to the other would tend to impinge more upon upper cheek teeth than upon the lower. They are not only set on a wider perimeter than the lower teeth but the raphe passes diagonally from the hamulus of the medial pterygoid almina above to the more laterally situated posterior end of the mylohyoid line of the mandible below. This constricting force operates while the teeth are separated, while the bulk of the tongue has been moved forwards and while it is less capable (in conjunction with the mylohyoids) of exerting a commensurate lateral thrust upon the upper dento-alveolar structures.

Few crossed bites are to be found in the deciduous dentition where the antero-posterior arch relationship is normal. They often are seen, of course, when the occlusion is Class III but the mechanism there can be explained on different grounds. Many crossed bites develop gradually from five or six years onwards in the continued presence of this mode of swallowing.

The deformities which are supposed to result from the habit of thumb or finger sucking have not been discussed but will be recognised as being similar to the varieties of deformities just described. The developmental defect which leads to a persistence of this poor oral behaviour is prone to lead also to persisting sucking habits. The habits tend to operate in mouths where conditions are already not favourable for a satisfactory dentition. The habits more often exacerbate than initiate trouble. It is on these grounds that one can explain why an occasional case of thumb sucking produces no symptoms at all.

Before leaving this subject of behaviour which tends to disperse incisor relations one might mention that the upper lip does not always continue to contribute to an anterior seal during swallowing. When the incisor relationship is moulded to a very adverse one the upper lip may at last cease to endeavour to make contact with the lower lip, and during swallowing a part of the upper incisors remains visible. The everted margin of the lower lip makes a seal with the upper incisal edges and with the ventral surface of the front of the tongue. It is an inelegant way of making a seal, but a tongue pressed against the back of the upper anterior teeth and supported by a taut lower lip makes a perfectly efficient one for the purpose of swallowing. This late inability of the upper lip to remain normally covering the upper incisors can thus be secondary. There is a discrepancy in upper and lower incisor relationship, but not because of a primary failure of the upper lip. The upper lip has merely become physiologically redundant. There are upper lips which do literally seem to be short. There are lips which even during the first years of life have come to be quite superfluous to the making of an anterior seal during swallowing because of a very poor incisor relationship in the deciduous dentition. Just as later on a poor permanent incisor relationship can enable or encourage an efficient seal to be made without the aid of the upper lip, so a poor deciduous incisor relationship can cause an upper lip to fall into still

earlier disuse. The only difference between learning to swallow without using the upper lip thus early and learning the same habit at seven years is that the early habit follows a primary discrepancy of the deciduous incisor area, which it incidentally tends to fix, while the late habit can follow an incisor discrepancy of the permanent dentition which may have newly arisen from the moulding forces of adverse muscular behaviour.

Careful watching of the lower lip of a child in the process of swallowing without using its upper lip and thus exposing the permanent upper incisors to view brings to notice two main ways in which the lower lip operates to form a seal. It can be drawn back and upwards forming a taut sling, the action appearing to be laborious, or it can move behind the upper incisors with little effort. If one looks further and tries to see what the tongue does in these two types of lower lip behaviour one discovers that the tongue of the child with the taut lip has moved forwards enough through the separated incisors to cause the lower lip to be lying against its ventral surface, re-creating the old infantile contact between the lower lip and tongue. The tongue of the child with the inert lower lip has not moved forwards. The teeth are not separated much, or they are not separated at all, and the lip is merely trapped between upper and lower incisors. It is helpful to try to recognise the difference between these two variations of behaviour for an improvement is more readily obtained in the incisor relationship of the child with the inert lower lip.

There is a polarity between certain dental deformities which is most unlikely to be accidental. The association between a crossed bite and retroclined upper and lower incisors is rare; so too is the association between anterior open bite and retroclined incisors. Children with retroclined incisors usually have good radial relations with an excessive incisor overlap. If the mode of swallowing of these children is watched it is seen to have lost its essential suckling character. The tongue is not raised and moved forwards to exert a thrust in the upper incisor region to propel food or saliva back towards the isthmus of the fauces akin to the compression of the areola of the breast to express milk. The tongue stays within the dental arches. The lower lip does not lie against the ventral surface of the protruded tongue, nor does one ever see these children maintaining that infantile resting contact between the tongue and lower lip that we see associated with anterior open bites. The mode of swallowing is, however, abnormal in other respects. The teeth are separated in the act. There is obvious tension of the sealed lips taking them back towards the withdrawn tongue. As the lower incisors erupt they fail to move adequately forwards. They tend to be retroclined and to show similar errors already described for the behaviour which disperses upper and lower incisors. Admittedly there is a forward pressure on the lower fronts exerted by the tongue acting in conjunction with the mylohyoids but the comparative inactivity of the lips seen in normal swallowing is missing. The lower incisors are subjected therefore in this abnormal mode of swallowing to an added resistance from the front.

As the permanent upper incisors subsequently move down into this adverse muscular field they too are subjected to the extra resistance of the tense upper lip. They too fail to assume a normal inclination. They tend towards retroclination. By the time they are fully erupted their tips lie well inside the lower lip whose tension controls them with equal efficiency. The more they are retroclined the more the crowns are lowered behind the lower lip. The perimeter of the anterior part of the dental arches tends to be lessened and some degree of imbrication of the teeth becomes necessary. The retroclination leads to an increased overbite, a condition which comes about without any secondary occlusal rise of lower incisors, but which nevertheless can be increased still more by secondary rise if local opportunities permit.

The absence of crossed bites in these cases with tendencies towards incisor retroclination is due to the fact that the front of the tongue during swallowing remains blunt and stays within the dental arches which are flattened anteriorly, thus in no way diminishing its thrust upon the upper cheek teeth.

During the act of mastication the same balanced interplay of the internal and external musculature which positioned food precisely between the teeth provided a muscular environment which fostered upper and lower arches with well knit radial relations. The abnormal type of swallowing does nothing to upset good radial relations. It is the suckling behaviour of tongue and lips during swallowing which disrupts radial relations.

There is a feature in both varieties which is interesting. It is the degree to which the mandible is separated from the maxilla at the moment of swallowing. In a dozen cases where swallowing was suckling in character and where there were various degrees of overjet the separation of the mandible varied from 2 mms. to 9 mms. In a second group showing fundamentally good radial relations and varying degrees of incisor retroclination the mandible was separated from 2 mms. to 7 mms. In both groups where the *widest separation* of the mandible was seen there was the *deepest overbite*. At the other end of the scale where the separation of the mandible was less the overbite was less or there was an anterior open bite.

One sees parted lips with well positioned incisors, with proclined and retroclined ones. Parted lips at rest are not related to any particular incisor picture and do not seem to have any direct adverse moulding effect upon the incisors. Parted lips by themselves even encourage a treated case to relapse, but they can be a pointer to other behaviour which is damaging to good incisor relationship. The lower lip which is drawn back against the ventral surface of the tongue during swallowing is the very lip which will often fall away from the upper lip when the child is at rest. It is the less obvious behaviour during swallowing which is damaging rather than the passive failure of the lips to remain together during rest.

The suckling tongue behaviour tapers away in some children to what seems to be a closing down of the teeth on a soft and bulging tongue. The tongue is not tensed and moved forwards to bring an upward thrust against the lingual surfaces of the upper incisors and adjacent palate. Neither upper or lower lip is particularly active and there is no eversion of the margin of the lower lip. The whole act is not reminiscent of suckling except for the sight of the tongue between the arches if the lips are parted with the fingers. Then there is a wide separation of the dental arches during swallowing in cases with postural pre-normal occlusion. They have an excessive overbite. The separation is such that the overbite is usually reduced to nil. The tongue does not protrude between the incisors though it does have the opportunity of protruding between the cheek teeth. This type of swallowing bears no resemblance to the behaviour of the suckling infant. Since postural prenormal occlusion can be accidentally produced by the early loss of deciduous molars it would seem that the mode of swallowing here is secondary to the position of the teeth.

In many cases the suckling tongue behaviour gradually becomes modified or less intense. The fact that a proportion of anterior open bites improve naturally encourages the view. Behind a dental deformity the behaviour which brought it about may already be sufficiently improved to support an improvement in the positions of the teeth if only someone will insert the appropriate apparatus, and treatment of deformities associated with the suckling tongue should begin early to afford the child as many formative years as possible with an improved dentition. Errors of radial relations of the teeth have

little opportunity for natural correction. The crossed bite is fixed by the stresses of mastication operating on the adverse cuspal lock of the cheek teeth. The poor antero-posterior incisor relationship enforces the lower lip wholly or in part to remain between the incisors whenever an anterior seal is made.

As for treatment of cases with upper and lower incisor retroclination it is more difficult. The oro-facial muscular behaviour pursues its predestined course despite improvements which may be made in the position of the teeth with appliances. Retroclination and imbrication tend to return and one's thoughts are led towards making a reduction in the number of teeth. Opportunities then occur for further retroclination. It is doubtful whether early orthodontic treatment has any advantage in this group.

These remarks have been made with no special reference to fundamental antero-posterior errors in the relationship of the apical area of the upper and lower incisors to each other. The work of Downs, contrasting the angles S.N.A. and S.N.B., the work of Bjork with his angles of upper and lower prognathism, Ballard's studies of skeletal patterns all in their way show that there are fundamental errors in incisor apical relationship. It alters to varying degrees the response of the incisor crowns to the two contrasting muscular environments and it is of importance when treatment is being considered. The region of the apices of teeth is more remote from the muscular activities described and therefore less susceptible to their adverse pressures. Both the growth of the skeleton and muscular behaviour are predominantly under genetic control. Where the apical area of the upper and lower incisors bears a Class III relationship the persisting suckling behaviour during swallowing would tend to fail to produce as large an overjet as one would see if the incisor apical areas were more normally related. It would all the more easily cause the upper cheek teeth to move into a crossed bite position. In cases where the incisor apical area bears a Class II relationship the same muscular environment would tend to mould the upper and lower incisors into a relationship producing a more severe degree of overjet. There would be less tendency for crossed bites to appear, and the lower incisors would show less retroclination.

In cases with a Class II incisor apical relationship which exhibited the "blunt tongue" swallow there would be a marked retroclination of the upper centrals and an excessive overbite which would render treatment difficult. The more that is known of the interplay of skeletal growth and muscular behaviour the more clearly can the unfortunate practising orthodontist see how best to make a feasible compromise with Nature.

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A Photoelectric Myodynagraph for Directing Recording of Oral Muscle Forces: Herbert I. Margolis, Professor of Orthodontics, Prem Prakash, Instructor in Anatomy, and Kenneth Fried, Assistant in Graduate Orthodontics, Department of Orthodontics, Tufts College Dental School, Boston, Mass.

A photoelectric "myodynagraph" was devised for the purpose of measuring and recording forces of tongue, lips, and cheeks.

The sealed air system, connected to a photoelectric recording mechanism, consists of five components:

1. *The mouthpiece* consists essentially of a rubber bellows with a lead of polyethylene tubing. A coil spring in the bellows controls the amount of air displacement by a given force. Changing the resistance of the coil spring permits use of the instrument for different sensitivity ranges. Two mouthpieces are used to cover the ranges involved in the rest, swallowing, and maximum effort forces. The mouthpieces are connected to

2. *two three-way stopcocks* to connect either of the two mouthpieces to the recorder or to the outside atmosphere. Influence of temperature differential between the room and the patient's mouth is eliminated by connecting the mouthpiece to the atmosphere until the temperature expansion of the air column is dissipated (10 to 15 seconds). The mouthpiece is then connected to

3. *the tambour* of the basic instrument of the photoelectric mechanism. Pressure applied on the mouthpiece is transmitted through the column of air to the rubber diaphragm of the tambour. This in turn activates

4. *the photoelectric recording mechanism* and the pressure is recorded on a moving roll of paper.

5. *The calibrator* is specially designed to permit recordings to be converted in terms of grams per unit area.

Repeated calibrations for precision and accuracy have demonstrated the low range of error (less than 5 per cent).

A procedure for myometric evaluation of lip and tongue forces has been developed. Repeated recordings on the same children have shown this procedure to be reliable.

Myodynametric studies are currently in progress using the photoelectric myodynagraph. These direct muscle force recordings are correlated with data from a parallel study using electromyographic technique.

An Observation Which May Clarify the Location of Bolton Point in Oriented Cephalometric Radiographs: John A. Henkle, D.D.S., M.S., David W. Baumgartner, D.D.S., William M. Ditto, B.S., D.D.S., University of Michigan Dental School, Department of Orthodontics, Ann Arbor, Mich.

In the study of orthodontics the problem of measuring growth and development is of paramount importance, both in determining the time to initiate treatment and in the observation of case progress. In order to obtain this information we must rely, largely, on oriented cephalometric radiographs. However, these radiographs have little value unless we can establish a plane or point that will serve as an orientation center. Such a criterion was established by the Bolton Study. It was this study that introduced Bolton Point into our orthodontic vocabulary.

Bolton Point is defined as the highest point in the profile of the notches at the posterior end of the condyles on the occipital bone.[1] This point is readily ascertained on properly oriented headplates of children until the age of 10 to 12 years when the developing mastoid process superimposes over the area. Al-

though Bolton Point has been often discussed, we were unable to locate in the literature any proved method of establishing its location when it cannot be directly observed.

In the hope of correcting this difficulty, we conducted an experiment to explore the possible relationships of Bolton Point with surrounding, observable landmarks of the cranium and the first cervical vertebra. This was accomplished by utilizing ten specimens of the head and neck opened by midsagittal section. Into each left half-head small lead shot, 1.4 mm. in diameter, was inserted at the following locations: nasion, orbitale, porion, opisthion, Bolton Point, and basion. These half-heads were then oriented with central ray passing through porion to obtain lateral headplates.

Evaluation of this material disclosed that Bolton Point can be located with remarkable accuracy on a perpendicular from Frankfort horizontal plane drawn tangent to the most anterior portion of the curve formed by union of the posterior arch and lateral mass of the first cervical vertebra. The average error using this method was 0.1 mm. In cases where porion cannot be accurately determined, because of the type of cephalometer employed or other difficulties, the plane from nasion through the center of sella turcica can be employed in like manner. The average deviation using this plane was 0.25 mm.

All the specimens available for this study were adults of undetermined age. In the application of this method of determining Bolton Point to longitudinal cephalometric studies it was found that the accuracy increased in direct proportion to the age of the individual and is most applicable after the approximate age of 15 or 16.

At present our study is preliminary with reference to the location of Bolton Point vertically on this perpendicular. The criticisms and assistance of other investigators are invited to further our solution of this problem.

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News and Notes

American Association of Orthodontists

The American Association of Orthodontists will hold its fiftieth annual session May 16 through 20, 1954, at the Palmer House in Chicago, Ill. The Local Arrangements Committee is continuing its efforts to arrange one of the most successful meetings in the history of the Association. Plans have already been completed for the usual special features of the Sunday buffet supper, stag dinner, International luncheon, and Golden Anniversary luncheon.

Members are particularly urged to bring their wives to this meeting. Chicago is an ideal convention city, and the Ladies Entertainment Committee is preparing special events for their entertainment while the scientific sessions are being held. The facilities of the Palmer House are excellent for such purposes. The hotel is centrally located in the heart of Chicago's famous Loop, within walking distance of most of the shopping, night club, and theater centers, and equally convenient to the museums and art galleries. The climax of the social events will be the reception and dinner dance in honor of President and Mrs. James W. Ford.

The preliminary program of the scientific sessions was published in the January issue of the AMERICAN JOURNAL OF ORTHODONTICS. Additional listings to the program will be published in a later issue of the JOURNAL. These new entries will include a list of the table clinics, an exhibit of material submitted in 1953 by applicants for certificates to the American Board of Orthodontics, and other events such as the prize essay, research programs, and exhibits by the manufacturers of orthodontic appliances.

Early hotel reservations made directly with the Palmer House are advised. This fiftieth annual meeting is one that you will not want to miss.

Research Section Meeting of the American Association of Orthodontists

In accordance with the policy of recent years, time will be set aside for research reports at the coming meeting of the American Association of Orthodontists. Any individual desiring to report on a current research problem, completed or in progress, may do so by communicating with Dr. Thomas Speidel, Department of Orthodontics, School of Dentistry, University of Minnesota, Minneapolis, Minn.

Each application should be accompanied by the author's name, address, and institution with which he works, if any. An abstract of 200 words should be forwarded at the same time for consideration of publication in the AMERICAN JOURNAL OF ORTHODONTICS. Please state whether the abstract will be read at the meeting or presented by title. The abstracts should be in the hands of the committee not later than April 15, 1954, in order to be included in the program supplement.

Presentation time will be limited to ten minutes.

JOHN R. THOMPSON, CHAIRMAN
RESEARCH COMMITTEE.

American Board of Orthodontics

The next meeting of the American Board of Orthodontics will be held at the Palmer House in Chicago, Ill., May 11 through May 15, 1954. Orthodontists who desire to be certified by the Board may obtain application blanks from the secretary, Dr. C. Edward Martinek, 661 Fisher Bldg., Detroit 2, Mich.

Applications for acceptance at the Chicago meeting, leading to stipulation of examination requirement for the following year, must be filed before March 1, 1954. To be eligible an applicant must have been an active member of the American Association of Orthodontists for at least three years.

The Northeastern Society of Orthodontists

The Annual Meeting of the Northeastern Society of Orthodontists will be held at the Commodore Hotel, New York, N. Y., on March 8 and 9, 1954. Members of the American Association of Orthodontists may obtain invitations by writing to Dr. Oscar Jacobson, 35 West 31st St., New York, N. Y.

Pacific Coast Society of Orthodontists

NORTHERN COMPONENT

The regular meeting of the Northern Section, Pacific Coast Society of Orthodontists, was held at the University of Washington, Oct. 19, 1953.

The scientific session extended from 9 A.M. to 4 P.M. and consisted of a round-table question-and-answer period by Drs. Stoller, Cline, Rees, Riedel, and Walley, and moderated by Emery Fraser. In the afternoon Al Moore spoke on scientific evaluation of the S. Kloehn's headcap as used for Class II, Division 1 cases with no appliance on the lower. Both events were well received, and the members are grateful to the clinicians.

George McCulloch was unanimously elected Chairman to serve for 1954.

Gerald Dohner was elected Secretary-Treasurer to serve for 1954 and 1955, also unanimously.

Arnold Stoller noted that we should have members of the Legislative Committee from this area, British Columbia, and Alaska.

CENTRAL COMPONENT

The meeting of the year was, as usual, the annual Christmas party, held at the Family Club, Wednesday, Dec. 9, 1953.

SOUTHERN COMPONENT

The regular quarterly meeting was called to order at 2:45 P.M. by Chairman Robert Whitney at the Chapman Park Hotel on Dec. 11, 1953.

Arnold E. Stoller of Seattle, Wash., spoke on "Patient Appraisal." In his talk, he noted what facts are vital to your records, how to approach the parent and patient to obtain correct information about their problem, and how to promote harmonious public relations within our practices.

Don MacEwan of Seattle, Wash., in his talk on "General Appraisal of the Denture Area," gave a simple and practical approach to diagnosis by utilizing three planes of the denture.

Lloyd Chapman presented a talk on "One Solution to Deep Overbite Cases." In cases that do not respond to the usual methods of bite-opening he uses a "Lower Bite Raiser." This is an acrylic splint which covers the lower occlusal surfaces of the teeth and a portion of the buccal surfaces.

Don MacEwan gave a talk on "Analysis of Lateral Cross-Bites" in which he stressed the path of closure and other pitfalls that may lead to a false diagnosis of the problem.

Rose Cohen Memorial Lecture

The first Rose Cohen Memorial Lecture sponsored by the Division of Periodontology, Columbia University Dental School.

Essayist: Dr. Robert Moyers, Professor of Orthodontics, University of Michigan School of Dentistry.

Subject: The Physiology of Centric Relation.

Time and Place: Wednesday evening, March 31, 1954, at 8:00 P.M. in Amphitheatre A at Columbia University Dental School, 630 West 168th St., New York 32, N. Y.

All members of the profession are invited.

University of Tennessee

The University of Tennessee announces plans in the making for a new ten-chair orthodontic clinic.

The school will conduct an eighteen-month full-time orthodontic course for qualified students, which will be directed by Dr. F. N. Weber.

University of North Carolina

The School of Dentistry, University of North Carolina, will admit its second class of graduate students in orthodontics, leading to certification or the Master's Degree, in June, 1954. Communications may be directed to Dean, School of Dentistry, University of North Carolina, Chapel Hill, N. C.

Notes of Interest

Murray J. Klauber, D.D.S., announces the opening of his office at 405 Linwood Ave., Buffalo 9, N. Y., practice limited to orthodontics.

Dr. Leonard J. Seide, formerly associated with Dr. J. A. Salzmann of New York, wishes to announce the opening of his own office at 11 West 42nd St., near Fifth Avenue, New York, N. Y., practice limited to orthodontics.

Joseph Zeger, D.D.S., announces the opening of his office at 125 Murray St., Binghamton, N. Y., practice limited to orthodontics.

OFFICERS OF ORTHODONTIC SOCIETIES

The AMERICAN JOURNAL OF ORTHODONTICS is the official publication of the American Association of Orthodontists and the following component societies. The editorial board of the AMERICAN JOURNAL OF ORTHODONTICS is composed of a representative of each one of the component societies of the American Association of Orthodontists.

American Association of Orthodontists

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Secretary-Treasurer, Curtis L. Benight - - - - - - - 1001 Republic Bldg., Denver, Colo.

Southern Society of Orthodontists

President, Leigh Fairbank - - - - - - - - - - - 1726 Eye St., NW, Washington, D. C.
Secretary-Treasurer, M. D. Edwards - - - - - - - 132 Adams Ave., Montgomery, Ala.

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Vice-President, Ott Voight - - - - - - - - - - - Medical Arts Bldg., Houston, Texas
Secretary-Treasurer, Fred A. Boyd - - - - - - - 1502 North Third St., Abilene, Texas

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